MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LXVII. FEBRUARY 8, 1907. NO. 4

ANNUAL GENERAL MEETING.

Mr W. H. MAW, PRESIDENT, in the Chair.

The Report of the Auditors of the Treasurer's accounts for the year 1906 was read, and is given on p. 220.

The Annual Report of the Council was partly read; see pp. 217 to 299.

The Address was delivered by the President, after which the Gold Medal was handed to the Secretary for transmission to Professor Ernest William Brown, to whom the Medal had been awarded for his researches in the Lunar Theory (see pp. 300 to 313).

The President having appointed the Scrutineers, the Society proceeded to the ballot for Officers and Council for the ensuing year. The names of those elected are given on p. 314.

The thanks of the Meeting were given to the retiring Officers, and also to the Auditors of the Treasurer's accounts and to the Scrutineers of the ballot.

Edgar T. Adams, 5 Warkworth Street, Cambridge, and the Cottage, Halstead, Essex,
Robert Jonckheere, Observatoire Stella, Roubaix (Nord), France,
John Stewart, Chief Officer, R.M.S. "Empress of China," The Willows, Wallasey, Birkenhead, and
Samuel Veevers, Normanton, Kimberley Drive, Great Crosby, near Liverpool,

were balloted for and duly elected Fellows of the Society.

The following Candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

Arthur Neville Brown, M.A., Schoolmaster, Ludgrove, New Barnet, Herts (proposed by Col. E. E. Markwick) ;

Harry Cooper, 19 Cromer Road, Eastville, Bristol (proposed by W. F. Denning) ;

Phanindralal Gangooly, M.A., Premchand Roychand Student, University of Calcutta (proposed by Asutosh Mukhopadhyay) ; and

William Newsam McClean, 42 Durdham Park, Bristol (proposed by Sir David Gill).

Report of the Council to the Eighty-seventh Annual General Meeting of the Society.

The following table shows the progress and present state of the Society :—

	Patron	Honorary Members	Fellows		Associates	Total
			Compounders	Annual Subscribers		
1905 December 30	1	2	259	398	49	709
Since elected	...	+ 1	+ 2	+33	+1	...
Deceased	...	...	− 5	− 9	−2	...
Resigned	...	...	...	− 6	...	...
Removals	...	...	+ 4	− 4	...	...
Expelled	...	...	...	− 3	...	...
1906 December 31	1	3	260	409	48	721

Major Hills' Account as Treasurer of the Royal

RECEIVED.

	£	s.	d.	£	s.	d.
Balances, 1905 December 31 :—						
At Bankers', as per Pass-book	299	0	2			
Cheques not credited till 1906	7	18	5			
In hand of Assistant Secretary on Account of Turnor and Horrox Fund	4	13	11			
In hand of Assistant Secretary on Petty Cash Account	8	19	10			
				320	12	4
Dividends :—						
£1,250 Metropolitan 3-per-cent. Stock ...	35	12	8			
£932 19 0 Metropolitan 2½-per-cent. Stock ...	22	3	4			
Half-year's Dividend on £1,484 17 5 Swansea Corporation 3½-per-cent. Stock	24	13	9			
Half-year's Dividend on £1,584 17 5 Swansea Corporation 3½-per-cent. Stock	26	7	0			
£3,400 East Indian Railway 3-per-cent. Debenture Stock	96	18	0			
£3,200 London and North-Western Railway 3-per-cent. Debenture Stock	91	4	0			
£4,000 Midland Railway 2½-per-cent. Debenture Stock	95	0	0			
£500 Lancashire and Yorkshire Railway 3-per-cent. Consolidated Preference Stock ...	14	5	0			
£1,860 Gas Light and Coke Co. 3-per-cent. Debenture Stock	53	0	2			
£1,650 Commercial Gas Co. 3-per-cent. Debenture Stock	47	0	6			
				506	4	5
Received on account of Subscriptions :—						
Arrears	128	2	0			
Annual Contributions for 1906	596	8	0			
,, ,, in advance	12	12	0			
Admission Fees	73	10	0			
First Contributions	52	10	0			
				863	2	0
Composition Fees...				87	3	0
Sales of Publications, &c. :—						
At Williams & Norgate's, 1905	11	16	0			
At Society's Rooms, 1906	94	0	8			
Sales of Photographs, 1906	35	12	6			
				141	9	2
Income Tax refunded by Commissioners of Inland Revenue				26	10	6
Bequest of the late Rev. A. S. Farrar				100	0	0
Sale of £932 19 0 Metropolitan 2½-per-cent. Stock				719	9	7
				2,764	11	0

Audited and found correct, 1907 Jan. 8 :
G. J. NEWBEGIN.
A. E. CONRADY.
W. W. BRYANT.

Astronomical Society, from 1906 *January* 1 *to December* 31.

PAID.

	£	s.	d.	£	s.	d.
Assistant Secretary: Salary	250	0	0			
,, ,, Editing Society's Publications	50	0	0			
Clerk's Salary	75	0	0			
				375	0	0
House Duty	2	12	6			
Fire Insurance	9	9	6			
				12	2	0
Printing, &c.:—						
Memoirs, vol. lvi. (Spottiswoode & Co.)	649	19	3			
Monthly Notices, ,, ,, ...	376	16	0			
Eclipse Report, 1905 (Harrison & Sons)	17	3	0			
List of Fellows and Miscellaneous (Spottiswoode & Co.)	25	4	0			
Photo-blocks in *Annual Report*	0	14	9			
				1069	17	0
Computation of Ephemerides in *Monthly Notices* ...				15	0	0
Turnor and Horrox Fund, purchase of books for Library				12	7	11
Reproduction of Photographs, Hinton & Co. ...				35	4	2
Cataloguing astronomical literature for the International Catalogue of Scientific Literature ...				30	0	0
Expenses of Meetings	16	19	0			
Lantern expenses	8	12	0			
Time Signal: rental of wire	5	0	0			
				30	11	0
Postage and Telegrams	79	9	6			
Carriage of Parcels	14	13	4			
Stationery (Spottiswoode & Co.)	4	17	6			
Sundry Stationery and Office expenses	5	10	7			
				104	10	11
Illuminating Address (Benjamin Franklin Centenary)				3	8	0
House expenses: Allowance and sundry expenses	59	0	7			
Coal and Gas	42	8	3			
Electric Lighting	18	14	10			
Fittings and Repairs	12	8	7			
Sundries	4	10	9			
				137	3	0
Purchase of £100 Swansea Corporation 3½-per-cent. Stock (Investment of Bequest of the late Rev. A. S. Farrar)				105	16	0
Purchase of £379, 15 2 Swansea Corporation 3½-per-cent. Stock				395	0	0
Power of Attorney for sale of Metropolitan 2½-per-cent. Stock				0	11	6
Bankers' deductions on cheques				0	3	0
Repayment of £400 loan from Bank, with interest				401	12	7
Cheques outstanding from 1905				16	19	6
Balances, 1906 December 31:						
At Bankers', as per Pass-book	14	1	0			
In hand of Assistant Secretary on account of Turnor and Horrox Fund	4	6	0			
In hand of Assistant Secretary on Petty Cash Account	0	17	5			
				19	4	5
				£2,764	11	0

Report of the Auditors.

We have examined the Treasurer's accounts of receipts and expenditure for the year 1906, and have found and certified the same to be correct. The cash in hand on December 31, 1906, including the balance at the bankers', etc., amounted to £19, 4*s.* 5*d.*

The overdraft of £400 at the bank has been repaid, but it has been found necessary to sell £932, 19*s.* Metropolitan 2½-per-cent. Stock, which realised £719, 9*s.* 7*d.*

£379, 15*s.* 2*d.* Swansea Corporation 3½-per-cent. Stock has been purchased, in addition to the investment of a bequest of £100 from the late Rev. A. S. Farrar, received during the year. The result has been that the expenditure for the year has exceeded the income by about £200, chiefly in consequence of the large amount of the bills for printing. In this connection we are glad to find that a change of printers has taken place, which we trust will result in a considerable reduction of this item.

The books, instruments, and other effects in the possession of the Society have been examined, and they appear to be in a satisfactory condition, with the exception of some of the instruments in the basement, with regard to which we regret to find that so far no practical result has followed from the recommendation made by the Auditors last year to eliminate those of no practical value or historic interest. We desire to repeat this recommendation with greater emphasis, as it is a matter which obviously grows more pressing each year.

We have laid on the table a list of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting of the Society, with the amount due against each Fellow's name.

(*Signed*) Walter W. Bryant.
G. J. Newbegin.
A. E. Conrady.

1907 *January* 11.

Bequests to the General Funds of the Society.

The Carrington Bequest (1876): A sum of £2,000 Consols. Sold in 1899, and stands now in £1,881 14*s.* London and North-Western Railway 3-per-cent. Debenture Stock.

The McClean Bequest (1905): A sum of £2,000. £1,600 of this sum invested in the purchase of £1,484 17*s.* 5*d.* Swansea Corporation 3½-per-cent. Stock.

The Farrar Bequest (1906): A sum of £100. Invested in Swansea Corporation 3½-per-cent. Stock.

Trust Funds.

The Turnor Fund: A sum of £464 18*s*. East Indian Railway 3-per-cent. Debenture Stock; the interest to be used in the purchase of books for the Library.

The Horrox Memorial Fund: A sum of £103 6*s*. East Indian Railway 3-per-cent. Debenture Stock; the interest to be used in the purchase of books for the Library.

The Lee and Janson Fund: A sum of £334 10*s*. 9*d*. East Indian Railway 3-per-cent. Debenture Stock; the interest to be given by the Council to the widow or orphan of any deceased Fellow of the Society who may stand in need of it.

The Hannah Jackson (*née Gwilt*) *Fund*: A sum of £309 18*s*. 6*d*. East Indian Railway 3-per-cent. Debenture Stock; the interest to be given in Medals or other awards, in accordance with the terms of the Trust.

Assets and Present Property of the Society, 1907 January 1.

	£	*s*.	*d*.	£	*s*.	*d*.
Balances, 1905 December 31 :—						
At Bankers'	14	1	0			
In hand of Assistant Secretary on Account of Turnor and Horrox Fund	4	6	0			
In hand of Assistant Secretary on Petty Cash Account	0	17	5			
				19	4	5
Due on account of Subscriptions :—						
4 Contributions of 5 years' standing	42	0	0			
8 ,, 4 ,, ...	67	4	0			
9 ,, 3 ,, ...	56	14	0			
33 ,, 2 ,, ...	138	12	0			
60 ,, 1 ,, ...	126	0	0			
	430	10	0			
Less Contributions paid in advance	12	12	0			
				417	18	0
Due for Photographs sold				0	15	0
Due from Messrs Williams & Norgate for sales of Publications, 1906				44	18	1

£3,400 East Indian Railway 3-per-cent. Debenture Stock, including the Turnor Fund, the Horrox Memorial Fund, the Lee and Janson Fund, and the Hannah Jackson (*née* Gwilt) Fund.

£3,200 London and North-Western Railway 3-per-cent Debenture Stock (including the Carrington Bequest).

£4,000 Midland Railway 2½-per-cent. Debenture Stock.

£500 Lancashire and Yorkshire Railway 3-per-cent. Consolidated Preference Stock.

£1,860 Gas Light and Coke Co. 3-per-cent. Debenture Stock.

£1,650 Commercial Gas Co. 3-per-cent. Debenture Stock.

£1,250 Metropolitan 3-per-cent. Stock.

£1,864 12*s.* 7*d.* Swansea Corporation 3½-per-cent. Stock (including £1,800 of the McClean Bequest of £2,000).

£100 Swansea Corporation 3½-per-cent. Stock (being Investment of Canon Farrar's Bequest).

Astronomical and other Manuscripts, Books, Prints, Photographs, and Instruments.

Furniture, &c.

Stock of Publications of the Society.

Celestial Photographs.

The following is a list of reproductions of Celestial Photographs published by the Royal Astronomical Society for sale to the Fellows :—

R.A.S. Ref. No.	Subject.	Photographed by
1	Total Solar Eclipse, 1889 January 1	W. H. Pickering
2	Total Solar Eclipse, 1893 April 16	J. M. Schaeberle
3	Total Solar Eclipse, 1886 August 29	A. Schuster
4	Nebulæ in the *Pleiades*	Isaac Roberts
5	Nebula M 74 *Piscium* (N.G.C. 628)	Isaac Roberts
6	Great Nebula in *Orion*	Isaac Roberts
7	Milky Way near M 11	E. E. Barnard
8	Milky Way near Cluster in *Perseus*	E. E. Barnard
9	Comet *c* 1893 IV. (Brooks), 1893 October 21	E. E. Barnard
10	Comet *a* 1892 I. (Swift), 1892 April 7	E. E. Barnard
11	Nebula about *η Argus*	David Gill
12	Portion of Moon (Hyginus-Albategnius)	Loewy and Puiseux
13	Comet *c* 1893 IV. (Brooks), 1893 October 22	E. E. Barnard
14	Comet *c* 1893 IV. (Brooks), 1893 October 20	E. E. Barnard
15	Comet *c* 1893 IV. (Brooks), 1893 November 10	E. E. Barnard
16	Comet *a* 1892 I. (Swift), 1892 April 26	E. E. Barnard
17	Comet *f* 1892 III. (Holmes), 1892 November 10	E. E. Barnard
18	Comet *a* 1892 I. (Swift), 1892 April 18	E. E. Barnard
19	Portion of Moon (Alps, Apennines, &c.)	Loewy and Puiseux
20	Nebula in *Andromeda*	Isaac Roberts
21	*Jupiter*, 1892 September 26	Lick Observatory
22	Cluster M 13 *Herculis* (N.G.C. 6205)	W. E. Wilson
23	Total Solar Eclipse, 1893 April 16 (5 sec.)	J. Kearney
24	Total Solar Eclipse, 1893 April 16 (20 sec.)	J. Kearney
25	The Moon (Age $7^d\ 3^h$)	Lick Observatory
26	The Moon (Age $12^d\ 6\frac{1}{2}^h$)	Lick Observatory

R.A.S. Ref. No.	Subject.	Photographed by
27	The Moon (Age $16^d\ 18^h$)	Lick Observatory
28	The Moon (Age $23^d\ 8^h$)	Lick Observatory
29	The Sun, 1892 February 13	Roy. Obs. Greenwich
30	The Sun, 1892 July 8	Roy. Obs. Greenwich
31	Portion of Moon (Region of Maginus)	Loewy and Puiseux
32	The Moon (Age $14^d\ 1^h$)	Lick Observatory
33	Portion of Moon (Ptolemæus, &c.)	Lick Observatory
34	Portion of Moon (Mare Serenitatis)	Lick Observatory
35	Portion of Moon (Clavius, Licetus, &c.)	Lick Observatory
36	Portion of Moon (Regiomontanus, &c.)	Lick Observatory
37	Portion of Moon (Tycho, Thebit, &c.)	Lick Observatory
38	Portion of Moon (Theophilus, &c.)	Lick Observatory
39	Total Solar Eclipse, 1896 August 9 (3 sec.)	S. Kostinsky
40	Total Solar Eclipse, 1896 August 9 (26 sec.)	A. Hansky
41	Cluster M 56 *Lyræ* (N.G.C. 6779)	
42	Nebulæ M 81, 82 *Ursæ Majoris* (N.G.C. 3031, 3034)	
43	Cluster M 56 *Lyræ* (enlarged) (N.G.C. 6779)	
44	Solar Corona, 1871 December 12, Baikul	H. Davis
45	Solar Corona, 1875 April 6, Siam	Lockyer and Schuster
46	Solar Corona, 1878 July 29, Wyoming	W. Harkness
47	Solar Corona, 1882 May 17, Egypt	Abney and Schuster
48	Solar Corona, 1883 May 6, Caroline Island	Lawrance and Woods
49	Solar Corona, 1885 September 9, Wellington, N.Z.	Radford
50	Solar Corona, 1886 August 29, Grenada, W.I.	A. Schuster
51	Solar Corona, 1887 August 19, Japan	M. Sugiyama
52	Solar Corona, 1889 January 1, California	W. H. Pickering
53	Solar Corona, 1889 December 22, Cayenne	J. M. Schaeberle
54	Solar Corona, 1893 April 16, Fundium	J. Kearney
55	Solar Corona, 1893 April 16, Brazil	A. Taylor
56	Great Nebula in *Orion*	W. E. Wilson
57	Dumb-bell Nebula, *Vulpecula* (N.G.C. 6853)	W. E. Wilson
58	Spiral Nebula, *Canes Venatici* (N.G.C. 5194–5)	W. E. Wilson
59	Ditto (enlarged) (N.G.C. 5194)	W. E. Wilson
60	Annular Nebula, *Lyra* (N.G.C. 6720)	W. E. Wilson
61	Meteor Trail and Comet Brooks, 1893 November 13	E. E. Barnard
62	Total Solar Eclipse, 1898 January 22 (5 sec.)	W. H. M. Christie
63	Total Solar Eclipse, 1898 January 22 (20 sec.)	W. H. M. Christie
64	Solar Corona, 1896 August 9, Novaya Zemlya	G. Baden-Powell
65	Solar Corona, 1898 January 22, Pulgaon, India	E. H. Hills
66	Nebula in *Andromeda*	Roy. Obs., Greenwich

R.A.S. Ref. No.	Subject.	Photographed by
67	Spectrum of Sun's Limb, 1898 January 22	E. H. Hills
68	Annual Nebula, *Lyra* (N.G.C. 6720)	Lick Observatory
69	Dumb-bell Nebula, *Vulpecula* (N.G.C. 6853)	Lick Observatory
70	Spiral Nebula, *Canes Venatici* (N.G.C. 5194–5)	Lick Observatory
71	Spiral Nebula, *Ursa Major* (N.G.C. 5457)	Lick Observatory
72	Trifid Nebula, *Sagittarius* (N.G.C. 6514)	Lick Observatory
73	Great Nebula in *Orion*	Lick Observatory
74	Cluster M 13 *Herculis* (N.G.C. 6205)	Lick Observatory
75	Solar Surface with Faculæ, 1893 August 7	G. E. Hale
76	Faculæ and Prominences, 1892 June 25	G. E. Hale
77	Total Solar Eclipse, 1898 Jan. 22 ($\frac{2}{3}$ sec.)	W. H. M. Christie
78	Nebula H V, 14 *Cygni* (N.G.C. 6992)	W. E. Wilson
79	Portion of Moon (Theophilus, &c.)	Yerkes Observatory
80	Total Solar Eclipse, 1900 May 28 (30 sec.)	E. E. Barnard
81	Comet 1901 I., 1901 May 4	Roy. Obs., Cape of G. H
82	Comet 1901 I., 1901 May 6	Roy. Obs., Cape of G. H.
83	Comet 1901 I., 1901 May 9	Perth Obs., W. Australia
84	Solar Surface with Faculæ, 1895 August 18	H. Deslandres
85	Solar Prominences, 1894 April 11	H. Deslandres
86	Nebula about Nova *Persei*, 1901 September 20	G. W. Ritchey
87	Nebula about Nova *Persei*, 1901 November 13	G. W. Ritchey
88	Total Solar Eclipse, 1901 May 18 (10 sec.)	F. W. Dyson
89	Total Solar Eclipse, 1901 May 18 (40 sec.)	F. W. Dyson
90	Comet *b* 1902 III. (Perrine), 1902 Sept. 29	Roy. Obs., Greenwich
91	Portion of Moon (Mare Serenitatis, &c.)	Yerkes Observatory
92	Portion of Moon (Rough Crater Region, Mare Nubium)	Yerkes Observatory
93	Portion of Moon (Tycho, Theophilus, &c.)	Yerkes Observatory
94	Portion of Moon (Bullialdus to Copernicus)	Yerkes Observatory
95	Portion of Moon (Copernicus, enlarged)	Yerkes Observatory
96	Great Nebula in *Orion*	Yerkes Observatory
97	Great Nebula in *Orion* (Central portion)	Yerkes Observatory
98	Nebula in *Andromeda*	Yerkes Observatory
99	Nebula in *Cygnus* (N.G.C. 6960)	Yerkes Observatory
100	Nebula in *Cygnus* (N.G.C. 6992)	Yerkes Observatory
101	Cluster M 13 *Herculis* (N.G.C. 6205)	Yerkes Observatory
102	Cluster M 15 *Pegasi* (N.G.C. 7078)	Yerkes Observatory
103	Solar Surface with Faculæ	Yerkes Observatory
104	The Moon, 1900 April 5	P. Puiseux
105	The Moon, 1902 November 13	P. Puiseux

R.A.S. Ref. No.	Subject.	Photographed by
106	The Moon, 1903 February 6	P. Puiseux
107	The Moon, 1903 September 12	P. Puiseux
108	Nebulosity about 15 *Monocerotis*	E. E. Barnard
109	Milky Way about β *Cygni*	E. E. Barnard
110	Nebulosity near α *Cygni*	E. E. Barnard
111	Milky Way near χ *Cygni*	E. E. Barnard
112	Star Cloud in *Sagittarius*	E. E. Barnard
113	Milky Way in *Cepheus*	E. E. Barnard
114	Milky Way about M 8	E. E. Barnard
115	Milky Way about θ *Ophiuchi*	E. E. Barnard
116	Milky Way near N.G.C. 6475	E. E. Barnard
117	Great Nebula near ρ *Ophiuchi*	E. E. Barnard
118	Milky Way about 58 *Ophiuchi*	E. E. Barnard
119	Milky Way near *Omega* nebula	E. E. Barnard
120	Star Cloud in *Sagittarius*	E. E. Barnard
121	Nebula about ν *Scorpii*	E. E. Barnard
122	Sun, 1905 January 30	Roy. Obs., Greenwich
123	Sun-spot, 1905 January 30	Roy. Obs., Greenwich
124	Sun, 1905 January 31	Roy. Obs., Greenwich
125	Sun-spot, 1905 January 31	Roy. Obs., Greenwich
126	Sun, 1905 February 2	Roy. Obs., Greenwich
127	Sun-spot, 1905 February 2	Roy. Obs., Greenwich
128	Sun, 1905 February 3	Roy. Obs., Greenwich
129	Sun-spot, 1905 February 3	Roy. Obs., Greenwich
130	Sun, 1905 February 5	Roy. Obs., Greenwich
131	Sun-spot, 1905 February 5	Roy. Obs., Greenwich
132	Sun, 1905 February 8	Roy. Obs., Greenwich
133	Sun-spot, 1905 February 8	Roy. Obs., Greenwich
134	Nebula near ψ *Eridani*, 1905 January 8	Max Wolf
135	Nebula M 33 *Trianguli* (N.G.C. 598)	Isaac Roberts
136	Nebula in *Perseus* (N.G.C. 1499)	Isaac Roberts
137	Nebula in *Monoceros* (N.G.C. 2237–9)	Isaac Roberts
138	Nebula H V. 24 *Comæ* (N.G.C. 4565)	Isaac Roberts
139	Nebulæ H V. 42, &c., *Comæ* (N.G.C. 4631)	Isaac Roberts
140	Nebulæ H V. 37 *Cygni* (N.G.C. 7000?)	Isaac Roberts
141	Nebula Index Cat. 405 *Persei*	Isaac Roberts
142	Clusters in *Perseus* (N.G.C. 869, 884)	Isaac Roberts
143	Cluster H VI. 30 *Cassiopeiæ* (N.G.C. 7789)	Isaac Roberts
144	Eclipse, 1905 August 30 (5 sec.)	W. H. M. Christie
145	Eclipse, 1905 August 30 (20 sec.)	W. H. M. Christie

R.A.S. Ref. No.	Subject.	Photographed by
146	Eclipse, 1905 August 30 (7 sec.)	W. H. M. Christie
147	Eclipse, 1905 August 30 (20 sec.)	W. H. M. Christie
148	Eclipse, 1905 August 30 (Portion)	W. H. M. Christie
149	Region of Nebula ρ *Ophiuchi*	E. E. Barnard
150	Nebula ρ *Ophiuchi* (enlarged)	E. E. Barnard
151	Region of θ *Ophiuchi*	E. E. Barnard
152	Great Rift near θ *Ophiuchi*	E. E. Barnard
153	Great Star Cloud in *Sagittarius*	E. E. Barnard
154	Small Star Cloud in *Sagittarius*	E. E. Barnard
155	Region of Cluster M 11	E. E. Barnard

Nos. 44–55, Nos. 64, 65, and No. 147 form a series of corona photographs, oriented and reduced to the same scale.

The above photographs are now on sale to Fellows as prints, either platinotype or aristotype, mounted on sunk cut-out mounts, measuring 12 inches by 10 inches; also unmounted, and as lantern slides. Nos. 44–55 and Nos. 64 and 65 are also supplied as transparencies, $6\frac{1}{4}$ inches square.

Price of prints, mounted 1*s.* 6*d.* each, unmounted 1*s.* each; lantern slides, 1*s.* each; packing and postage extra.

Transparencies, $6\frac{1}{4}$ inches square (Nos. 44–55 and Nos. 64 and 65), 3*s.* 6*d.* each.

Orders to be addressed to W. H. Wesley, Burlington House, London, W. In ordering prints or slides the R.A.S. Reference No. only need be quoted, but in the case of prints it should be stated whether platinotypes or aristotypes are required, and whether mounted or unmounted.

The Gold Medal.

The Council have awarded the Society's Gold Medal to Professor Ernest W. Brown, F.R.S., for his researches in the Lunar Theory. The President, in his Address to the Society, gives the grounds upon which the award has been founded.

Publications of the Society.

During the past year vol. lxvi. of the *Monthly Notices* has been issued.

Vol. lvi. of *Memoirs* has been published :—

Thomas Lewis, Measures of the Double Stars contained in the *Mensuræ Micrometricæ* of F. G. W. Struve, collected and discussed; with an Introduction containing general deductions, a list of proper motions of fifty faint stars, and various other information in respect to double stars.

The Royal Society have decided to terminate the arrangement under which the Royal Astronomical Society has been permitted to have reprints of astronomical papers from the *Proceedings* and *Philosophical Transactions*. This decision, however, does not relate to Eclipse reports; and the Reports to the Joint Meeting of the two Societies on 1905 October 19 (reprinted from the *Proceedings*) has been issued to Fellows as a separate publication. The following paper, reprinted from the *Philosophical Transactions*, will shortly be issued as an Appendix to the *Memoirs*:—

F. W. Dyson, Determination of wave-length from spectra obtained at the total solar eclipses of 1900, 1901, and 1905.

Obituary.

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year :—

Fellows :—Raphael Louis Bischoffsheim.
Rev. John Bone.
Everard Home Roberts Coleman.*
Thomas R. Dallmeyer.
Robert Isaac Finnemore.
Joseph H. Freeman.
Joseph Gledhill.
Charles Jasper Joly.*
John Joynson.
Alfred Edward Nicholls.
Robert Rawson.
William John Reynolds.
Philip E. Sewell.
Rev. George Venables.
Associates :—Samuel Pierpont Langley.
Jean Abraham Chrétien Oudemans.

Obituary notices are also given of the following, who died in January 1907 :—

Agnes Mary Clerke (Honorary Member).
William Johnston.
William Simms.

Raphael Louis Bischoffsheim, son of Louis Bischoffsheim, founder of the Bischoffsheim Bank, was born at Amsterdam, 22nd July 1823. At an early age he was sent to Paris, there to study for entry to the Central School of Arts and Manufactures, into which he was admitted in 1839. On leaving the school he was attached to the staff of the Railway de la Haute-Italie as Inspecting Engineer. Later, he took over the direction of his father's bank, finally settling down in Paris, where, on 24th April 1880, he obtained full letters of naturalisation for "services rendered to the country." For many years he was well known for his liberality towards anything tending to promote the welfare of literature, science, and art, and the value of his donations was finally acknowledged by his admission, as life member, to the Académie des Sciences on 16th June 1890.

Especially fond of astronomy, he presented a costly equipment

* Obituary in Annual Report, 1905.

to the Paris Observatory, the Equatorial Coudé and a Meridian Circle being due to his munificence; he subsidised the Observatory on Mont Blanc, and contributed towards the expense of redetermining the length of an arc of the meridian at Quito.

But he will, above all, be remembered as the founder of the Observatory of Nice, in the organisation of which he was assisted by the experience and authority of the Bureau des Longitudes. Having brought into existence this great institution, he entrusted its direction to the able and energetic astronomer Perrotin. He generously endowed the observatory, and finally assured its future by presenting it to the University of Paris. This foundation has rendered the name of Bischoffsheim familiar to astronomers in every land, and the *Annales* of his Observatory will form the imperishable memorial of its founder.

M. Bischoffsheim was elected a Fellow of the Royal Astronomical Society on the 14th January 1881. G. B.

The Rev. John Bone was the second son of John and Mary Bone, of Melton Lodge, Surrey. He was born on 20th October 1834. He graduated at King's College, London, in theology, with first-class honours, in 1861, and in the same year he was ordained Deacon by the Bishop of Rochester. He was first licensed to the curacy of Radwell, Herts, and in 1862 was ordained priest. In 1863 he became curate of Poulton-le-Fylde. Thence he went to Melksham, Wilts, and from 1865 to 1873 he occupied the position of curate-in-charge of North Meols, Lancashire. He also served on the committee of the Southport Infirmary. In 1863 he married Eliza, youngest daughter of Samuel and Mary Mayhew, of Camberwell Park, Surrey.

As incumbent of St Thomas' Church, Lancaster, Mr Bone "read himself in" on the last Sunday in May 1873, so that he had held the living exactly thirty-three years. He was the oldest beneficed clergyman in Lancaster in point of length of time he had held the living.

For some years he conducted a class in astronomy at the Storey Institute, and was never happier than when introducing others into the mysteries and delights of solar science. Whenever any astronomical phenomenon was observable in Lancaster his was the brain that guided local observers, and by his personal observation of the heavens he has at various times been able to render good service to the cause of astronomical research. In the work of the Lancaster Astronomical and Scientific Association he took a deep interest, contributing several papers on various phases of the planetary, solar, and lunar systems. There are many in Lancaster who entertain feelings of gratitude to Mr Bone for the lead he gave them in their first essays in astronomy. The establishment of the Greg Observatory, of which he was honorary Director, was mainly due to his perseverance.

The sudden death of his wife in July 1903 was a great blow to him, and for a time he was prostrated. He rallied, however,

and was able to resume and discharge his ministerial duties up to within a few days of his death, which occurred on Sunday, 27th May, at the age of seventy-one. He leaves three sons and two daughters.

Mr Bone was elected a Fellow of the Society on 6th April 1887.

Agnes Mary Clerke was born, 10th February 1842, at Skibbereen, a small country town in a remote part of the County Cork. Her father was John William Clerke; her mother was a sister of the late Lord-Justice Deasy.

Very early in life she was attracted by the wonders of the heavens, and before the age of fifteen had definitely formed the intention of writing a history of astronomy,—had even actually begun it. Always delicate constitutionally, she found her chief pleasures in study and in music. In 1861 the family moved to Dublin; in 1863 to Queenstown; and the years 1867–77 were spent in Italy, chiefly at Florence, where Miss Clerke studied assiduously in the public library, and wrote her first important article, "Copernicus in Italy," which was accepted by the *Edinburgh Review* (October 1877).

The family then returned to England and settled in London. In 1885 appeared Miss Clerke's *History of Astronomy in the Nineteenth Century*, a work now in its fourth edition, and regarded as the standard work, continuing the *History* of Grant.

Miss Clerke's other works, published at intervals, are as follows:—*The System of the Stars*; *Familiar Studies in Homer* (in part only astronomical); *The Herschels: A Concise History of Astronomy*; *Problems in Astrophysics*; *Modern Cosmogonies*.

Besides these works she contributed fifty-five articles to the *Edinburgh Review*, mainly on subjects connected with Astrophysics; the articles on astronomers to the *Dictionary of National Biography*; some articles on astronomers and on astronomical subjects to the *Encyclopædia Britannica*; and innumerable articles to *Knowledge*, to *The Observatory*, and other periodicals.

In later years Miss Clerke was a frequent attendant at the meetings of the Royal Astronomical Society, and in 1903 received the great honour of being elected an Honorary Member of the Society.

She was also a member of the British Astronomical Association, and constantly attended its meetings.

Miss Clerke was not a practical astronomer; but the three months' visit paid by her in 1888 to the Cape Observatory, as the guest of Sir David and Lady Gill, enabled her to write with increased clearness and confidence. In 1892 she was awarded for her astronomical works the Actonian Prize of 100 guineas by the Royal Institution.

Miss Clerke's ideals of life were lofty; and, loving and lovable, her character was in complete harmony with them. In all her writings, Truth was ever her goal.

Accomplished in many directions, astronomy to the last was her chief intellectual interest.

She died, after a comparatively short illness—in perfect peace, and fully conscious to almost her last moment—on 20th January 1907. M. L. H.

Thomas Rudolphus Dallmeyer was born in May 1859. He was the second son of the late Mr J. H. Dallmeyer, photographic optician, his mother being the daughter of another famous optician —Andrew Ross.

He was educated at Mill Hill School and at King's College, London, and it had been intended that he should go through the full university course in mathematics and science. Unfortunately, however, his elder brother died suddenly in 1878, and his father's health also becoming impaired, it was considered desirable that young Dallmeyer should relinquish his studies after passing the first examination for B.Sc., in order to take a share in the management of the firm founded and made famous by his father. His father died in 1885, having handed over the business to his son the year before.

He was thoroughly familiar with photographic optics in all its branches. Perhaps his best work was that done in introducing and perfecting the telephotographic lens, and in working out its theory and applications in his excellent book on "Telephotography."

In 1886 he became a member of the Royal Photographic Society, and the interest which he took in the work of that society eventually led to his election as President for the years 1900, 1901, and 1902.

Although he never contributed any papers to the Society, he rendered many services to astronomy by way of supplying efficient tools. In addition to ordinary telescopes and photographic lenses, of which many must have been used for serious astronomical work, he supplied the six-inch Rapid Rectilinear lens with which the Cape Photographic Durchmusterung was carried out.

He died on Christmas Day 1906, after an illness of only a few days.

He was elected a Fellow of the Royal Astronomical Society in May 1888. A. E. C.

Robert Isaac Finnemore was the son of the land-steward to the Archbishop of Canterbury. When Mr Finnemore was eight years old the family emigrated to Natal, taking passage in the ill-fated *Minerva*, which was wrecked off the Natal coast, the family being saved with great difficulty. It was the intention of his parents that he should become a minister, and he studied as a pupil at Bishopstowe under Bishop Colenso. The buildings at Bishopstowe being destroyed by fire, he returned home to Maritzburg, where, in 1858, he entered the Government service as pupil-assistant in the Surveyor-General's office. The following year, while not yet seventeen, he was promoted to be second

clerk. In 1864 he rose to be chief clerk and draughtsman, and was also admitted a Government land-surveyor. Being of an ambitious disposition, and the Surveyor-General's department offering no prospect of further advancement, he succeeded in being transferred to the Attorney-General's department, where he worked as law-clerk under Sir Michael Galwey for eleven years. In 1876 he accepted the appointment of Postmaster-General. During his tenure of office he introduced separate delivery windows for Europeans and natives, but his attempt to establish a postal delivery was unsuccessful. In 1877 he was appointed Master of the Supreme Court, which post he held till March 1881. He was Chairman of the Zulu War Commission appointed to decide upon the compensation to be paid to relatives of those who had fallen during the war; and for his "admirable report," drafted with the assistance of Sir Henry Bale and Dean Green, he received the thanks of the Government and an expression of the Governor's high appreciation. In 1894 a new office of Crown Solicitor and Parliamentary Draughtsman was created, and the then Prime Minister, Sir John Robinson, offered the post to Mr Finnemore. It was in this capacity that he, in 1896, accompanied Sir Walter Hely-Hutchinson to Volksrust as legal adviser in connection with the Jameson Raid. In November 1896 he succeeded to the Supreme Court Bench, and during part of 1903 and 1904 he acted as Chief-Justice, and towards the end of the latter year he retired.

Apart from these services as a public official, Mr Finnemore did much to advance the cause of philanthropic, religious, and social organisations. He was an enthusiastic Freemason, and held the office of District Grand Master from 1882. To the cause of temperance he devoted much time; and as a member of the Wesleyan Methodist Church he did much for the advancement of that body in Natal. He was, besides, a Fellow of each of the following Societies:—Royal Meteorological, Royal Historical, Zoological, Royal Geographical, Statistical, Anthropological Institution, Royal Colonial Institute, and the Imperial Institute.

Mr Finnemore died 27th July 1906.

He was elected a Fellow of the Society in November 1890.

Joseph H. Freeman was born, 18th April 1845, at Stratford, Essex, where he resided all his life. A schoolmaster by profession, he devoted much time to popular lectures on astronomy. His preference for astronomy was due to his grandfather, Mr John Freeman, who was an intimate friend of Mr Epps, the first Assistant Secretary of the Royal Astronomical Society. Mr Freeman was for many years a most regular attendant at the Society's meetings. He died on 5th February 1906. He was elected a Fellow of the Society on the 10th November 1871.

Joseph Gledhill was born, 17th November 1837, at Bradford, Yorks. His early training was directed to the profession of a

schoolmaster, which he followed for some years. His own tastes, however, gradually won him over to the close prosecution of scientific study, and in 1868, when Mr Edward Crossley established his observatory in Halifax, he asked Mr Gledhill to undertake the work of observer. The measurement of double stars was a distinguishing feature of his work there, and the results were embodied in *A Handbook of Double Stars*, which was written with the co-operation of the Rev. J. Wilson, M.A. (now Canon of Worcester) and Mr Crossley. He also contributed several papers on planetary observations to the *Monthly Notices of the R.A.S.*

The erection of the 3-foot reflector in 1885 (built by Dr Common, and subsequently presented to the Lick Observatory by Mr Crossley) promised a more extended sphere of work, but it was found that, for purposes of exact observation, the climate of Halifax was hopelessly unsuitable, and the serious use of the telescope was soon discontinued.

After about two years of indifferent health, Mr Gledhill (soon after Mr Crossley's death in 1905) removed to Hoddesdon, Herts, where he died on 20th March 1906.

His scientific attainments were by no means a complete indication of his mental activity and varied tastes. He was an omnivorous reader, a very fair amateur violinist and organist, and, later in life, became an enthusiastic fisherman. Apart from his more serious work in astronomy, there are probably not a few amateurs living who have at some time or other felt their indebtedness to his ready and willing assistance in their little difficulties.

Mr Gledhill was elected a Fellow of the Society in May 1874.

F. H. C.

William Johnston was born, 10th August 1819, at "Stockholm Farm," in the parish of Dumfries, Scotland. He was for many years a furniture manufacturer in Gloucester, but later dealt in curios, becoming an authority both in England and America. In 1843 he married Miss Avery, of Gloucester, who died in 1898. He was interested in a variety of subjects, as may be judged from the titles of his pamphlets,—*The Machinery of the Heavens*; *The Immortality of all Living Creatures*; *Are Intoxicating Beverages Necessaries of Life?* He died on 10th January 1907, leaving four sons and four daughters.

Mr Johnston was elected a Fellow of the Society on 8th January 1897.

Alfred Edward Nicholls was born in 1866 at Stroud, Gloucestershire. Immediately on leaving school he went to sea, and after serving in all grades as a mariner, identified himself with a small nautical school in Limehouse, of which he became principal in 1894. Under his management it became one of the most successful schools of navigation in the country. On the completion of the Passmore Edwards Sailors' Palace at Limehouse, three years ago,

the school was transferred to that building, where it has since been carried on under the name of the King Edward VII. Nautical School, and has had many among its students who have risen high in the profession. Captain Nicholls was the author of several works on navigation and astronomy, including *Seamanship and Guide*, and *Concise Rules to Board of Trade Examinations*. He was a member of the British Astronomical Association, and had taken up work in connection with the Variable Star Section.

He died suddenly, from the result of an operation, on 4th March 1906, leaving a widow and six young children.

He was elected a Fellow of the Royal Astronomical Society in March 1905.

Robert Rawson was born at Brinsley, a small colliery village nine miles from Nottingham, on the 22nd July 1814. His father, John Rawson, was a man of very limited means, whose life seems to have been a long struggle against adverse circumstances.

Robert Rawson was a child of seven when he began work in the coal-mines of Messrs Barter & Walker at Eastwood, two or three miles from his home at Brinsley, and he never forgot the long walks in all weathers to and from the mines. It was during this sixteen years, when working as a collier, that he laid the foundation of his future success. One day he came across a periodical containing a variety of mathematical questions, to some of which he could see the answer; but not being able to master all, he made inquiries and was told that he wanted an "arithmetic." Accordingly, one Saturday afternoon, on leaving the pit, he walked into Nottingham and bought a second-hand arithmetic for twopence. This he used to find the answers to the particular questions; he never worked through it. In the same way he acquired an algebra, then an old *Euclid*, and more advanced works. In 1837, when Robert Stevenson commenced building the Manchester and Leeds Railway, Rawson obtained employment as clerk and draughtsman in a constructor's office at Rochdale. He did not seek this situation; it was offered under the following circumstances. A controversy arose in a local paper as to how the level of the road should be altered at a curve in the railway, so as to counteract the effect of centrifugal force. Rawson gave his solution, and a few days later the railway engineer sent for him. As he presented himself in collier's dress and spoke the colliers' dialect, there was at first some misunderstanding. In the end it was arranged that he should leave the mines and go to the office. When the railway was completed in 1842 he removed to Manchester and became a teacher of mathematics, and kept up a correspondence with the *York Courant*, the *Mathematician*, the *Lady's and Gentleman's Diary*. He also wrote papers on the "Summation of Series," "Definite Integration," etc. etc., which were published in the *Memoirs* of the Manchester Literary and Philosophical Society.

In 1845 he joined the Manchester Society, and two years later had a seat on its council, where he came into contact with leading

practical engineers and chemists. At this time he was employed by Stevenson to calculate the stress on the girders of the Menai Bridge, and by Eaton Hodgkinson to determine the strength of cast-iron pillars and other materials.

In 1843 the Admiralty established a school in each of the dockyards for the education of engineers and shipwright apprentices. The instruction was at first given by the dockyard officers, but in 1847 it was considered that properly qualified masters should be appointed. Hodgkinson, to whom the First Lord applied, recommended Rawson, who was rather dubious, as he had never had experience of school life, in fact had never set his foot inside a school. However, for a period of twenty-eight years he held the post at Portsmouth with credit to himself and advantage to his pupils. Many of those passing through his school are now filling places of high distinction in the service of the Admiralty and of the great shipbuilding yards. It will suffice to mention Sir Philip Watts, K.C.B., the present Director of Naval Construction; Sir John Durston, K.C.B., Engineer-in-chief R.N.; Sir James Williamson; and Professor Francis Elgar, F.R.S.

While at the dockyard school he was appointed by the Lords Commissioners of the Admiralty to make experiments, in conjunction with the master shipwright, John Fincham, to test the validity of Moseley's formulæ for the dynamical stability of ships. Moseley gives an account of these experiments in a paper entitled "On the Dynamical Stability of Ships and on the Oscillations of Floating Bodies," in the *Philosophical Transactions*, 1851, and speaks in high terms of Rawson's ability.

Rawson devised the screw compass, which determines at sight the pitch of the screw: for this invention he received the thanks of the Admiralty. In 1851 he published a treatise on *The Screw-Propeller: an Investigation of its Geometrical Properties*, and some elementary works on arithmethic, mensuration, and trigonometry.

The great bulk of Rawson's papers are in the *Memoirs* of the Manchester Literary and Philosophical Society, but some will be found in the British Association *Reports*, the Naval Architects' *Transactions*, and the *Messenger of Mathematics*. These papers deal with differential equations; prime numbers; friction of water; oscillation of floating bodies; stability of ships; screw propulsion, etc. etc., his last paper being on "Dr Ferrers' Theorem on Prime Numbers" in the *Messenger of Mathematics*, 1895.

In April 1894 he was placed on the commission of the peace for the county of Hampshire, and, notwithstanding his great age, he discharged his duties as a magistrate with great zeal and ability up to within a month of his death. He was twice married; first, in 1851, to Mrs Baldock, daughter of his friend John Fincham, and again, in 1870, to Miss Aylword, daughter of a former master shipwright in Plymouth Dockyard. There was no issue of either marriage. Mr Rawson was a man of active habits and temperate living, rising at 5 in the morning and retiring at 8.30

in the evening. His days were spent working in his garden, walking and cycling. In the spring of 1906, while out walking at 6 o'clock on a frosty morning, he slipped and bruised himself. An attack of influenza supervened, which developed into pneumonia, and on 11th March he died at the advanced age of ninety-two. Mr Rawson was one of those men who inspire affection and command the homage of heart as well as intellect. At his funeral, which took place 16th March 1906 at the Havant cemetery, were, besides the representatives of the leading county families and a number of his fellow-magistrates, many of his old pupils, some of whom had travelled great distances to pay their last tribute of respect.

Mr Rawson was an Associate of the Institute of Naval Architects, and a member of the London Mathematical Society. He was elected a Fellow of the Royal Astronomical Society on the 9th November 1889.

William John Reynolds was the eldest son of William Reynolds, a carmine manufacturer of Hackney. He was born at Clapton 2nd September 1845, and attended the local schools, and afterwards a boarding-school at Greenwich, and finally Homerton College, at that time under Dr Unwin. Being of a mechanical turn of mind, he was bound apprentice to a firm of pianoforte makers in Clerkenwell. This firm coming to an abrupt end, Reynolds became clerk in the office of the Metropolitan Drinking Fountain Association in Clement's Lane. At his father's death, he, in conjunction with his brother, carried on the manufacture of carmine at Hackney for many years. Finally he joined with Mr Fred Baddeley, forming the firm of Baddeley & Reynolds, engravers and die-sinkers, in the Old Bailey.

Mr Reynolds married in 1880 and had one daughter. He seems to have interested himself in many subjects, and especially in Horology and Astronomy, and often answered the questions of inquirers in the *English Mechanic*. He also interested himself in social matters, being at one time Secretary to the South Place Ethical Society, and was a man much esteemed amongst his acquaintances. His death occurred on 15th July 1906, at "Varna," Palmer's Green.

He was elected a Fellow of the Society on 11th June 1898.

Philip Edward Sewell was born in London on the 14th January 1822. His father, Isaac Sewell, was a member of the Society of Friends, and his mother (*née* Mary Wright) was a lady of some literary repute. His education commenced at Hackney Grammar School, then in charge of Canon Eden, and finished at the Friends' School at Stoke Newington. On leaving school he joined the London and County Bank at Brighton, of which his father was manager. Shortly afterwards he was entered for Cambridge University, but a breakdown in his health necessitating an outdoor life, he took up civil-engineering, under Mr C. E. Vignoles. In 1849 he married Sarah, youngest daughter of

Samuel Woods, of Tottenham. He was engaged in the construction of the Settle and Carlisle Railway, and subsequently in engineering work upon Seaham harbour. In 1853 he went to Spain as railway engineer, and while there he entertained the members of the Himalaya Eclipse Expedition in June 1860 at Santander, for which he received the thanks of the Society. In 1864 he accepted an appointment in Gurney's Bank; and when this bank, in 1896, assumed the style of Barclay & Co., Mr Sewell was elected one of the Directors for the Norwich District.

Mr Sewell was a man of broad sympathies. In the parish of Buxton, where he had property, he was greatly interested in the Reformatory for juvenile offenders, which he practically kept alive, both morally and financially. He was also an active worker on behalf of the Discharged Prisoners' Aid Society.

Mr Sewell was a justice of the peace, and was one of the original Aldermen appointed on the formation of the Norfolk County Council. Mr Sewell was twice married, but he died a widower, leaving one son, Mr Philip Edward Sewell.

Mr Sewell was elected a Fellow 11th January 1861, and died 6th February 1906.

William Simms, who died on 2nd January last at the age of eighty-nine, was the oldest Fellow of the Society, having been elected in 1851, three years before any existing Fellow. The names of Troughton and of Simms have been so long honourably associated with the history of practical astronomy that the opportunity may be taken to recall a few facts about the different individuals who have borne them.

Edward Troughton (1753–1835) was admitted as a young man to partnership with his uncle of the same name and his eldest brother John, who were settled in London as mathematical instrument makers. About 1782 the Troughtons established themselves in Fleet Street, where they commenced an independent business, called "Ye Orrery," as successors to a series of well-known artists (Wright, and subsequently Cole) who had previously occupied the same premises. After the death of his uncle and his brother John, Edward Troughton alone continued the business until 1826, when he took Mr William Simms (1793–1860) as his partner and successor. After Troughton's retirement in 1831, William Simms continued the business alone till his death in 1860, when he was succeeded by his son James Simms, the present sole proprietor.

William Simms had five brothers; one of them, Frederick Walter Simms (1803–1865), was for a short time previous to 1835 assistant at the Royal Observatory under Pond, and a Fellow of our Society; and another brother, James, was a manufacturer of ships' and other compasses in Greville Street, Hatton Garden. Our recently deceased Fellow, William Simms (1817–1907), was the son of this brother James, and was originally intended for his father's business. But about 1836 the construction of railways had commenced, and his uncle's occupation (of making astronomical

and surveying instruments) seemed so much more promising than that of a compass-maker, that he was led to apply to the well-known firm for a situation, which was easily found for him. He became superintendent of the business, and afterwards a partner with his cousin; but in 1871 (after being partner for some ten years) he retired, during a loss of health which he regarded as permanent, but which fortunately proved only temporary.

The *Monthly Notices* contain several papers by "William Simms jun.," * especially on the improvement of instruments. The hole in the central cube of the Greenwich transit-circle telescope was first suggested by him, according to the recollection of Mr James Simms; and (on the same authority) he greatly improved the cutting apparatus of the dividing machines, while as a hand-divider he could scarcely be excelled. For a long time he was employed upon the construction of the National Standard of Length, and greatly assisted the Rev. R. Sheepshanks in that work, a large number of the observations, as well as much in the way of construction, being due to him. He also helped the elder Lord Rosse, put up Mr Carrington's telescope, and did work at Bidston Observatory. His astronomical interests were wide in range; and his daughter (Mrs M'Lachlan) well remembers an occasion when letters announcing some interesting and novel observation made independently by Sir George Airy and himself crossed in the post. We learn from her also that observations on the Sun caused the loss of her father's eyesight.

While in business, and after his marriage in 1844 to Charlotte, daughter of Francis Needham, of Wymondham, Leicestershire, William Simms lived at Granville Square (in London), at Putney, and at Charlton. After his retirement he lived at Burnham, in Somerset; and afterwards in the Isle of Wight, at Ryde and Shanklin. He had one son, who is a surveyor in New Zealand, and the daughter above mentioned. His widow survives him, aged ninety-six, and also quite blind. The late Queen was much interested in the aged couple, and shortly before her death Mr William Simms was granted a small Civil List pension, on account of his blindness, caused by devotion to science.

He was born in London, 22nd June 1817; and died at Albert Lodge, Shanklin, I.W., 2nd January 1907. He was elected a Fellow on 10th January 1851 (the Report of Jurors of the great Exhibition of 1851 mentions his management of the Astronomical Exhibits), and served on the Council 1867–69. H. H. T.

The Rev. George Venables was born at Hamptongay, Oxon, 24th April 1821. He was educated at St Edmund Hall, Oxford, where he took the degree of Student of Civil Law. In 1843 he married Miss Davis of Loudwater, Berks, by whom he had six children. The wife and one daughter survive him. In 1852 he

* In one case there is some confusion with another "William Simms junr.," afterwards described as W. H. Simms. He was the *son* of William Simms the elder, and brother of the present sole representative of the firm.

was ordained priest by the Bishop of Oxford, and finally appointed as first Vicar of St Paul's, Chatham, 1855. In 1858 he accepted the private living of Friezland, in the West Riding of Yorkshire, which he left in 1870 to become Vicar of St Matthew's, Leicester. In 1874 he was transferred to the important vicarage of Great Yarmouth, and in 1881 he was made a Canon of Norwich Cathedral. Finally, on the nomination of the Lord Chancellor, he became Rector of Burgh Castle, near Great Yarmouth. While at Great Yarmouth he did much to restore the historic parish church, to which he presented a magnificent oak pulpit. Canon Venables was a prolific writer on Church matters. He was a member of the Royal Commission on Patronage, and was select Preacher at Cambridge in 1883. His death took place 30th December 1906, at the age of eighty-five. He was elected a Fellow of the Society on the 11th of January 1856.

Samuel Pierpont Langley was born at Roxbury, Massachusetts, on 22nd August 1834. After he had graduated at Boston High School in 1851, he took up civil-engineering and architecture as his profession. From childhood he had shown great devotion to scientific pursuits, especially to astronomy. He practised his profession for some thirteen years, but after spending part of the years 1864 and 1865 in travelling in Europe, and visiting foreign observatories and learned institutions, he decided on his return to devote his life to the pursuit of science.

His first scientific appointment was that of Assistant at the Harvard College Observatory in 1865. In the following year he was made Assistant Professor of Mathematics in the Naval Academy at Annapolis, a post he almost immediately relinquished to become Director of the Allegheny Observatory at Pittsburg, where he remained for twenty years.

In 1867–68 he was busy with the equipment of the observatory, and a little latter he arranged and carried out a plan for distributing standard observatory time to the existing railway system of the country. In 1869 he went to Kentucky, in charge of a party of the United States Coast Survey, to observe the total eclipse of the Sun, and in 1870 he joined a Government eclipse expedition and went to Jerez in Spain. The only other eclipse expedition he took part in was one to observe the eclipse of 1878 from the top of Pike's Peak.

His first interest at Allegheny was the Sun, and it was whilst he was there that he made his well-known drawings of sun-spots and other details of the Sun's surface. An eminent authority has said of these drawings that the better the detail of the Sun's surface is seen, the more closely does it resemble Langley's drawings.

It was about 1875 that he began to devote much attention to the measurement of the heat spectra of the Sun and other hot bodies. Experience convinced him of the insufficiency of the thermopile as a measuring instrument, and after four or five

years he was successful in the invention of the Bolometer. This instrument, as is well known, is an electrical thermometer on the principle of Wheatstone's bridge. With it he at once set to work to explore the infra-red spectrum of the Sun; he extended it to regions of ten times the wave-length of the visible spectrum and mapped the lines in it; other researches with the bolometer were on the action of the Earth's atmosphere in scattering and absorbing selectively the Sun's rays of all wave-lengths; on the infra-red spectrum of the Moon, and a determination of its temperature, which he found to be a little above 0° C.; an estimate of the constant of solar radiation by a new method; and on the connection between temperature and distribution of radiation in the spectrum of heated terrestrial sources. All this was done between 1880 and 1888.

In 1888 he was appointed Secretary of the Smithsonian Institution. The Smithsonian Institution officially represents the interest of the United States in science, and the chairman of its board of directors is the President of the United States. Its immediate affairs are administered by the secretary, who has charge of many and various scientific interests, such as the National Museum, the International Exchanges, the Bureau of American Ethnology, the National Zoological Park, and others. These administrative duties necessarily occupied much of Langley's time, and it was now impossible for him to devote the same personal attention to his scientific researches as before.

A few years after his appointment he founded the Smithsonian Astrophysical Observatory, the object of which was to increase our knowledge of the natural agencies which control climate and life. One of the most important of these he believed to be the amount of heat radiated to the Earth by the Sun, and at the time of his death he was engaged in the problem of finding whether the amount was constant, or varied sufficiently to affect the climate of the Earth. About the same time he improved his bolometer by adding to it a photographic arrangement to record its readings automatically and continuously: by its means it became possible to map the whole of the energy spectrum of the Sun in a few minutes.

Perhaps Langley was more widely known for his studies in the problem of flight than for his astrophysical work, or his able direction of a great institution. He had always been interested in the question of flight, and first took it up seriously in 1889. In 1891 he published his "Experiments in Aerodynamics," and in 1893 "The Internal Work of the Wind." In these papers he demonstrated the theoretical possibility of flight by means of large sustaining surfaces and mechanical motors, and for the remaining years of his life he gave much time and thought to its practical realisation. Large models of his design for a flying machine were successfully flown between 1896 and 1903, and he was encouraged by his success to construct an aerodrome large enough to carry a man. Two trials of this machine were made on the Potomac river in 1903, but were foiled by accidents in the launching, fortunately

without loss of life. No further trials were made owing to a combination of unfavourable circumstances, including failing health.

Langley's published papers are over a hundred in number. It was his aim in all his publications to write them in the simplest and clearest language, so that they might be understood by educated persons not specially read in the subject, and he took immense pains to try to achieve his aim. He was a Foreign Member of the Royal Society of London, a Correspondent of the Institute of France, Member of the Accademia dei Lincei of Rome, and of many others. He received the degree of D.C.L. from Oxford, and Sc.D. from Cambridge, besides many other honorary degrees; and he was a medallist of the Royal Society of London, the American National Academy of Sciences, and the Institute of France, and received the Diploma of the Royal Institution.

He had many interests outside his scientific work. One was psychical research, and for many years he was associated with both the American and the British Societies for Psychical Research. He showed a keen appreciation of the best in English and French literature, and had a special interest in George Borrow, of whose manuscripts he had a large collection. He was also much interested in the fine arts, and had a considerable knowledge of pictures.

He died on the 27th February 1906, at Aiken, South Carolina.

He was elected Associate of the Royal Astronomical Society in 1883. B. C.

Jean Abraham Chrétien Oudemans was born at Amsterdam on the 16th of December 1827. At the age of sixteen he went to the University of Leiden to study astronomy under Professor Kaiser, and took his degree in 1852. In 1853 he was appointed as Astronomer at the Observatory which was then established on the roof of the University building, and occupied himself mostly with observations and computations of planets, comets and variable stars, which are published chiefly in the *Astronomische Nachrichten*. His first astronomical publication, however, dates from 1846.

In 1856 Oudemans was named Professor of Astronomy at the University of Utrecht, but the following year he resigned his professorship to take up his appointment of Chief of the Geographical Service in the East Indian Colonies. There he determined, in different parts of the archipelago, the latitude and longitude of a great number of stations, and executed with a staff of engineers the triangulation of the whole island of Java. He found time for more strictly astronomical work, observing two total solar eclipses, and taking part in the observations of the transit of Venus in 1874 as Chief of the Dutch expedition to the island of Réunion, his colleagues being Professor Bakhuyzen and Professor Kaiser.

In 1875 he returned to Europe, and became, for the second time, Professor of Astronomy and Director of the Observatory at Utrecht. This position he held till 1898, when he retired at the age of seventy years.

When in Batavia he published the first part of the measurement of the base line near Sunplak in Java, the second part being published shortly after his return to Holland. When all the observations for the triangulation of Java were completed, he was charged by the Government with their reduction. During the years 1891–1900 he published the results in four large volumes.

As a member of the Dutch Geodetic Committee, Oudemans had the direction of the geodetic astronomical observations, and in 1905 he published a volume containing the results of the observations of latitude and azimuth made at thirteen stations, together with a study of the instruments employed and of their different errors. Notwithstanding his occupation with his geodetic work, Oudemans published a great number of papers on different astronomical subjects, *e.g.* "On the theory of instruments"; "On the ring-system of Saturn"; "On the position of the equator of Mars"; "On the Moon's diameter"; "On the parallax of fixed stars."

He published also a popular work on astronomy for the schools in Java, and revised Kaiser's Popular Astronomy, *The Starry Heavens*.

Oudemans was indefatigably busy with astronomical work to the end of his life: only some few days before his death he corrected the proofs of his last paper, "On the mutual occultations and eclipses of the Satellites of Jupiter," published by the Academy of Sciences at Amsterdam. He was a painstaking astronomer, with a vast knowledge, who in all his work strove his utmost to attain the highest accuracy and completeness. He had a noble and open character, and was much esteemed and beloved by all who knew him.

His death at the age of seventy-nine took place, after a short illness, on 14th December 1906.

He was elected an Associate of the Royal Astronomical Society in 1883, and a Correspondent of the French Academy in 1901.

H. G. VAN D. S. B.

Proceedings of Observatories.

Royal Observatory, Greenwich.
(*Director, Sir William Christie, K.C.B., Astronomer Royal.*)

Transit Circle.—During the year 5877 observations of transits and 5605 of meridian zenith distances have been obtained. The Sun has been observed 123 times and the Moon 94 times. The lunar crater Mösting A has also been observed 47 times. Reflexion observations of stars have been obtained on 69 nights.

The object-glass of the transit-circle was repolished at the beginning of the year, but in the process the figure was affected owing to the thinness of the lenses, and it was not till the end of April that the refiguring was satisfactorily completed. There was consequently much interruption in the observations during the first four months of the year.

Some observations with the reversion prism, designed to ascertain whether the direction of motion had a systematic effect, revealed the fact that the adopted wire intervals were sensibly in error. It had been assumed that when one or two wires were renewed the intervals of the remainder were unaffected, but it now appears probable that the process of inserting new wires is liable to displace the existing wires. A redetermination of the intervals of the wires for the periods covered by the forthcoming Second Nine Year Catalogue, 1897–1905, was undertaken, 1200 transits being worked up in each year. The result of this extensive discussion disclosed sensible errors in the adopted wire intervals, but as these are of the nature of accidental errors, no corrections have been applied to the transits, the systematic effect on the catalogue places being presumably negligible.

The reductions for the Second Nine Year Catalogue for 1900 are progressing. The zones from the Pole to 15° N.P.D., Part ii. containing the astrographic reference stars, are completed, and the copy for press ready. Some 1200 of these stars which are common to the Carrington Catalogue for 1855 have been compared with it, and from the comparison, after corrections for systematic discordances have been applied, proper motions have been determined. These proper motions and those derived from the new reduction of Groombridge's Catalogue have been used by Mr Eddington as the data for a paper on the "Systematic Motions of the Stars," in which Kapteyn's two-star drift hypothesis has been examined and independently confirmed (*M. N.*, lxvii. p. 34).

The new working catalogue, as stated last year, consists of all reference stars down to $9^{m}\cdot0$ in the Oxford Astrographic Zone, *i.e.* between the limits of 24° and 32° north declination. The normal fundamental stars will also be observed.

Altazimuth.—This instrument has been used as a meridian transit instrument during the second and third quarters of the Moon for the observation of the Sun, Moon, planets, and the stars in Newcomb's Fundamental Catalogue. The instrument is reversed every two months, alternately by reversing in its Ys, and by turning the instrument through 180° of azimuth.

The total number of meridian transits obtained during the year is 1636, including 77 of the Moon's limbs, and 44 of the lunar crater Mösting A. The number of extra-meridian observations of the Moon obtained during her first and last quarters is 40.

A new set of wires was inserted in the instrument in October, and in connection with the determination of their intervals a re-determination has been made of the errors of the three screws of the Right Ascension, Polar Distance, and Position Micrometers. The third of these micrometers serves to readily connect the two former with each other, and thus simplifies the determination of their errors.

Reflex Zenith Tube.—During the year, 1170 double observations and 37 single observations have been obtained, the brighter stars having been observed over as long periods as possible. γ *Draconis* was observed on 82 days, β *Draconis* on 56 days, ι^2 *Cygni* on 41 days, and θ *Ursæ Majoris* on 27 days.

Occultations.—During the year 17 disappearances and 6 re-appearances of stars occulted by the Moon have been observed by one or more observers. The results have already been communicated to the Society.

28-inch Refractor.—A new working catalogue of double stars was brought into use in the course of 1906. This catalogue includes, as its main feature, the double stars discovered by Hough, the remaining pairs being selected from Struve, Otto Struve, Burnham, Hussey, and Aitken. The weather has not been at all favourable for double-star work, the long spells of non-observational weather causing serious interruptions in the programme of observation. However, the 414 stars observed have been measured, on the average, on two nights.

An analysis of the observations gives—

Hough Stars.

18	under	0″·5 separation
18	between	0·5 and 1″·0
36	between	1·0 and 2·0
165	over	2·0

Miscellaneous Stars.

37	under	0″·5 separation
45	between	0·5 and 1″·0
37	between	1·0 and 2·0
58	over	2·0

κ *Pegasi* was observed on 14 nights, δ *Equulei* on 9 nights, and 70 *Ophiuchi* on 11 nights. The measures of δ *Equulei* confirm the short period (5·7 years).

The equatorial and polar diameters of *Jupiter* were measured on 17 nights with the bi-filar micrometer, and also with the double-image. The satellites were measured on 2 nights. Owing to the necessity for renewing a portion of the wheel-work for opening the shutters of the dome, the 28-inch was out of use from June 27 to July 31.

Thompson Equatorial.—With the 26-inch refractor 63 photographs of *Neptune* and its satellite have been obtained on 24 nights.

With the 30-inch reflector 24 photographs of *J vi.* were obtained on 11 nights and 4 of *J vii.* on 3 nights from January 1 to February 15. During the whole of the 1905–6 opposition (from 1905 August 23 to 1906 February 15) 86 photographs of *J vi.* were obtained on 36 nights and 19 of *J vii.* on 15 nights. During the present opposition, up to December 31, 31 photographs of *J vi.* have been obtained on 16 nights, the series commencing on August 28, and 6 photographs of *J vii.* on 4 nights (November 17, 22, December 10 and 12).

Photographs of comets have been taken in the year 1906 as follows:—

Comet *c* 1905,	4	photographs on	4 nights.
a 1906,	19	,,	14 ,,
b 1906,	20	,,	15 ,,
d 1906,	21	,,	19 ,,
e 1906,	7	,,	6 ,,
g 1906,	5	,,	5 ,,

78 photographs of 31 minor planets have also been obtained.

These photographs were all taken for determination of position.

Photographs of the nebulæ, M. 51 Can. Ven. (100^m and 60^m), M. 57 Lyræ (5^m to 20^m), and M. 31 Andromedæ (100^m), have also been obtained.

In addition, a few photographs have been taken for instrumental adjustments.

As regards the measurement of photographs and reductions—

The printing of the *Eros* measures and reductions is complete, with the exception of the discussion of results. In the course of this discussion the errors of the réseau as photographed on the plates have been discussed with special reference to their effect on the determination of the solar parallax (*M. N.*, January 1907).

The photographs of *Neptune* and its satellite are measured and discussed as far as the end of the last opposition, and the results published.

The photographs of *J vi.* and *J vii.* for the opposition 1905–6, and of Comets 1903 *c*, 1904 *a*, 1904 *e*, 1905 *a*, 1905 *c*, 1906 *a*, and 1906 *b*, have been measured, and the results published.

The measures of photographs of Comets 1906 *d*, 1906 *e*, and 1906 *g* are in hand.

The minor planets photographed in the years 1903 and 1904 have been measured, and the results published. Those photographed in 1905 are ready for publication, and those observed in 1906 are in hand.

Astrographic Equatorial.—Work with this instrument has still mainly been confined to replacing chart plates which, though satisfactory in other respects, are, owing to slight photographic defects, unsuitable for production of enlarged prints. During the year 133 chart plates, 4 catalogue plates, 22 plates of the field round *Jupiter*, one of *Mars*, and one of Comet 1905 *c* were taken. Of the chart plates 30 were rejected, principally because they did not come up to the standard in showing faint stars or for photographic defects.

The measurement of the catalogue plates has been completed by remeasuring the images showing discordances in the Zones 85° to the Pole. The means of measures for these zones have been taken and copy for press prepared. The printing of the measures of Zones 80° to the Pole is practically finished, and the second volume of measures complete, with the exception of the Introduction. In view of the large overlap of the plates immediately surrounding the Pole, it was thought advisable for the plates from declination 87° to the Pole to measure all the stars within the limits of the réseau, and these measures have been printed on a different system to those of the lower zones, with reference numbers showing all the plates on which each star occurs. The assigning and printing of these reference numbers has taken more time than was anticipated.

The computation of the constants of the plates in the second volume has been begun during the year. Standard co-ordinates deduced from the places of the reference stars in the Greenwich Second Nine Year Catalogue, 1900, now in course of preparation, have been computed for the plates of the Zones declination 76° to 80° and 87° to the Pole, and the scale value and orientation constants computed for these plates, with the exception of those of Zone 76°.

The counting of the chart plates (declination 64° to the Pole) is now complete with the exception of a few fields for which better photographs will be obtained, 285 plates having been counted during the year.

Enlarged reproductions of the chart plates have been made for 213 plates during the year. The total reproduced to December 31 is 538, the six Zones 65° to 70° being complete, and the Zones 71° to 74° nearly half finished.

Photoheliograph.—Photographs of the Sun have been taken on 209 days with the Thompson (9-inch) Photoheliograph, and on 6 days with the Dallmeyer (4-inch) during the time that the 30-inch mirror was being resilvered, November 3–12, when the Thompson instrument was not available. Of the photographs taken, 576 have been selected for preservation. Photographs have

been received through the Solar Physics Committee from Dehra Dûn, India, up to 1906 November 27, and these have been further supplemented by photographs from the Observatory at Kodaikánal, India, and from the Royal Alfred Observatory, Mauritius. The daily record thus made up is complete, without break, from 1905 January 2 to 1906 November 27, the date of the last Indian photograph received. The last photograph received from Kodaikánal is dated 1906 September 13, and the last from Mauritius 1906 March 26. The photographs from these two observatories have all been measured; those from Dehra Dûn have been measured up to 1906 July 21, and those taken at Greenwich to 1906 May 28. The solar activity during the year has not been quite so great as in the previous year, but the work of measurement and reduction still continues to be very heavy.

Concurrently with this, the preparation of the Supplementary Photoheliographic Results, 1874 to 1885, referred to in the last Annual Report, has been carried on during the year, and is now approaching completion. Mr Maunder, after an inspection of the photographs stored at South Kensington, found there 35 photographs taken in Mauritius which filled 23 gaps previously existing in the record for 1878 and 1879, all of these days being occasions on which the Sun showed spots or faculæ, or both. These have been lent to the observatory, and have been measured and reduced, and the results incorporated with those previously published in the Greenwich volumes for those years, or by the Solar Physics Committee. The ledgers of spot groups for the twelve years 1874–1885 have been passed for press; the daily projected areas have been computed for the entire period; and the computation of the mean daily areas and mean latitudes of the spots for each rotation of the Sun and for each year alone requires completion, and is already in hand.

The Photoheliographic Results for 1905 have been passed for press.

Printing.—The copies of the volume of Greenwich observations for 1903 were distributed in April 1906, together with the New Reduction of Groombridge's Catalogue of Circumpolar Stars and the Determinations of Longitude 1888–1902. The volume for 1904 was distributed in November and December, with an Appendix—Meridian Zenith Distances of γ *Draconis* with the Reflex Zenith Tube 1886–1899; also the Meteorological Reductions, Part IV., Temperature 1891–1905.

The printing of the 1905 volume is nearly completed, and the second volume of the *Astrographic Catalogue* will shortly be ready for distribution. Other publications now in the press, and nearing completion, are the Heliographic Results, 1874 to 1885, and Measures of Photographs of *Eros* for determination of solar parallax.

Royal Observatory, Cape of Good Hope.
(Director, Sir David Gill, K.C.B., H.M. Astronomer.)

The new transit circle has been in regular use throughout the year in observations for the new Fundamental Catalogue, and in certain researches on the magnitude correction in R.A. which are subsequently mentioned. The Repsold-Struve method of observation has been continued without use of clockwork. Experiments have been continued with the clock-driven wire, and so long as the self-regulating motor preserves a nearly uniform rate the cone-apparatus and differential gear work to perfection, and the star can be maintained in perfect bisection on the travelling wire throughout the transit by pressing one or other of two keys, of which the action of one is to accelerate, the other to retard the rate of motion of the wire by 4 per cent. But unfortunately the rate of the motor varies by quantities fully greater than 4 per cent., so that, until this variation of rate is corrected, the perfection of bisection during the transit of a star cannot be maintained. It is proposed to substitute a weight-driven clockwork, similar to that on the astrographic telescope.

The underground azimuth marks have retained their constancy of relative azimuth in a remarkable manner.

The old non-reversible transit circle was employed in completing the observations of the list of stars of which observations were requested by Professor Boss, and of the miscellaneous stars used in the determination of latitude in connection with the Geodetic Survey, and stars of which occultations have been observed. This work was completed by the beginning of August. Since that time a series of observations of selected stars whose relative positions have been accurately determined by heliometer measurement has been made in order to determine the amount of personality of the observers depending on magnitude. That is to say, a bright star having two much fainter stars, the one preceding, the other following it, is selected—all three stars having nearly the same declination, and the fainter stars situated nearly symmetrically with respect to the brighter star. Heliometer observations of the position-angle and distance of the bright star with respect to the fainter stars obviously determine the R.A. of the bright star relative to the fainter stars, free from personality depending on the magnitude of the stars or of the adopted scale-value of the heliometer. This relative R.A. so found is compared with the relative R.A. derived from the meridian observations, with the satisfactory result that the magnitude corrections derived for Mr Power and Mr Pead with the old transit circle by means of screen observations are confirmed for stars from Mag. 4 to 8, whilst for the observers with the moving wire the magnitude correction is nearly zero.

The following observations have been secured with the meridian instruments:—

With the old Non-reversible Transit Circle :—

Number of transits	4665
Determinations of Z.D.	4032
,, collimation	93
,, level	239
,, azimuth	249
,, run	249
,, nadir	230
,, flexure	11

With the new Reversible Transit Circle :—

Number of transits	3590
Determinations of Z.D.	3627
,, collimation by collimators	48
,, collimation by reflection and reversal	41
,, level	422
,, azimuth	389
Observations of N. azimuth mark	370
,, S. ,,	369
Determinations of run	249
,, nadir	301
,, flexure	64

The following oppositions of the major planets have been observed with the heliometer during the year :—

	No. of Obs.	No. of Nights
Opposition of Neptune (1905–6)	38 *	6
,, Uranus 1906	64	7
,, Saturn 1906	33	4
,, Jupiter 1906	48	8

The following heliometer observations have been made during the year in connection with the triangulation of the comparison stars :—

Uranus 1903–5, Saturn 1900	101 observations.
Neptune 1905–8	86 ,,
Mars 1905	61 ,,
Jupiter 1905	17 ,,
Miscellaneous	87 ,,

The triangulation of comparison stars for Mars 1905, with 135 observations, is now complete. 212 observations in distance and 130 in position angle have been made in connection with the above-mentioned determinations of magnitude-errors in R.A. as observed with the transit circle.

Thirty-one observations each of distance and position angle of the components of α Centauri have been made by Mr J. M. Baldwin.

Comet 1905 *c* has been observed on 9 nights and Comet Finlay 1906 *d* on 11 nights with the heliometer.

* Including 20 observations in 1905.

At the request of Dr T. Banachiewicz, observations of the relative positions of Saturn and h_1 Aquarii were made on 4 nights.

Thirty-three separate phenomena of occultations have been observed, viz.—

Disappearances of stars at the dark limb .	14
Reappearances „ „ .	14
Disappearances „ bright limb	1
Disappearance of Saturn – 4 phenomena .	4

With the astrographic telescope the following work has been accomplished :—

Description of Plate.	No. of Plates.	No. of Exposures.	Duration of Exposure.
Triple exposure Chart plates .	15	45	20^m 20^m 20^m
Single exposure „ .	10	10	30^m
Catalogue plates, second series .	23	69	6^m 3^m 20^s
Kapteyn areas	14	28	30^m 30^m
Adjustment plates . . .	11	...	various
Experiments with Cooke lens .	10	...	„
Miscellaneous	5	...	„

The "Kapteyn-areas" plates were taken at the request of Professor J. C. Kapteyn in connection with his scheme for the determination of the parallaxes and proper motions of faint stars.

During the year 185 Catalogue plates, containing 103,296 stars, including 2167 standard stars, have been measured, both in direct and reversed positions of each plate; the standard stars being measured in like manner by each of the two observers by whom the alternate zones of the plate are measured. 18 plates measured in former years have since been rejected.

The total number of plates now measured is 1086, containing about 600,000 star-images, corresponding to over 250,000 different stars.

The actual state of the measurement on December 31 is as follows :—

	No. of Plates measured.			Copied for Press.		
Zone.	Before 1906.	During 1906.	Outstanding.	Before 1906.	During 1906.	Outstanding.
$-41°$	140	4	...	140	...	...
-42	144	...	...	144	...	...
-43	142	...	2	115	27	...
-44	131	1	12	66	$58\frac{1}{2}$	1
-45	138	2	4	19	108	3
-46	113	29	2	3	$82\frac{1}{2}$	38
-47	65	73	6	2	1	$67\frac{1}{2}$
-48	25	69	50	5	...	14
-49	1	6	113	1	...	...
-50	2	1	117	2	1	...
-51	0	0	120	0	0	...
	901	185	426	497	278	$123\frac{1}{2}$

The Victoria telescope has been employed principally for the determination of the radial velocities of stars by means of spectra photographed with the 4-prism spectrograph attached to the 24-inch telescope. The instrument was used on 113 nights for spectroscopic work, and photographs of 245 spectra were secured by Messrs Lunt and Simpson. 123 separate spectra have been measured, and the radial velocity computed by Messrs Lunt, Goatcher, and Baldwin; Mr Simpson has given much assistance in the reductions.

Mr Lunt has prepared a paper on "The presence of Europium in Stars," for communication to the Royal Society.

The 18-inch visual telescope has been employed on 17 nights for observations of Comet Finlay and Comet Metcalf, by Messrs Hough, Lunt, Baldwin, and Simpson.

Daylight observations of the position-angle and distance of the components of α Centauri were made on 8 days by Messrs Baldwin and Innes.

The printing of the Catalogue of 8560 Astrographic Standard Stars has been completed, and copies forwarded to Greenwich for distribution.

The Cape General Catalogue for 1900, based on observations with the 8-inch transit circle during the years 1900–04, and containing 2798 zodiacal stars and all C.P.D. stars not fainter than 8·5 mag. (except those of zone $-42°$ to $-50°$) which are not previously contained in any catalogue of precision, has been passed through press, and copies have been sent to Greenwich for distribution.

Meridian observations 1900–04. The outstanding sheets of this volume, containing the results of meridian observations 1900–04, all reduced to the equinox 1900, have been passed through press and sent to Greenwich for distribution. Vol. x. part 2 of the Annals of the Cape Observatory, containing researches by Mr Lunt on the spectra of Silicon and Fluorine, has been issued.

Vol. xii. part 2, containing Mr Cookson's observations with the heliometer of the relative distances and position angles of Jupiter's Satellites, and his derivation from them of the mass of Jupiter and the inequalities of the Satellites, and vol. xvi. part 3, containing Mr de Sitter's discussion of the inclination and nodes of the orbits of Jupiter's Satellites from photographs taken at the Cape in the years 1891, 1903, and 1904, have been delivered at Greenwich, and will be circulated at the next annual distribution. Vol. ii. part 5, containing meridian observations of the Sun, Mercury, and Venus during the years 1884–92; vol. ii. part 6, containing the results of occultations of stars by the Moon during the years 1896–1906; and vol. vii. part 1, containing heliometer observations of the major planets during the years 1897–1904, have been forwarded for press.

The Cape day-numbers for 1908–9 have been printed and distributed.

The reductions of the meridian observations with the 8-inch

transit circle are complete to the end of the year. The results have been forwarded to Professor Boss. The demand for early completion of the observations of the Boss-stars has delayed the reductions of observations made with the new transit circle. The right ascensions of the latter have been completely reduced and examined to 1906 October 25. The corrected circle readings have been derived to 1896 November 25, and the reductions to apparent place applied to 1905 November 23. Owing, however, to the absence of Mr Cox in England, the examination of the N.P.D. reductions has fallen considerably in arrear.

The constants for reduction of the Astrographic Catalogue plates for the zones $-41°$, $-42°$, and $-43°$ have been derived, as also those for 64 plates of zone $-44°$ and for 19 plates of zone $-45°$.

The heliometer observations of comets and of the conjunction of Saturn and *h* Aquarii have been completed and sent for publication to the *Astronomische Nachrichten*. The heliometer observations of sets of stars required for the determination of magnitude personal equation in meridian observing have been completely reduced, and a comparison made with the transit circle results.

The records of the seismograph have been regularly forwarded to Professor Milne during the year. A duplicate copy, at the request of the German Government, is supplied through the Consul-General for Germany, Cape Town, for transmission to the central station for the investigation of earthquakes at Strassburg.

The meteorological observations have, as usual, been communicated to the Meteorological Commission, Cape Town.

Colonel Morris has completed the reductions of the Geodetic Survey of the Transvaal and Orange River Colony, and he will return to England early in 1907.

The chain of triangulation connecting the northern end of the 30th meridian arc in the Transvaal with the existing triangulation in Rhodesia has been completed by Captain Gordon, R.E., in course of the year.

No reports have been received from Dr Rubin since May 1905 in spite of the most urgent requests made to him both directly and through the Administrator.

From reports obtained from Mr M'Caw, Dr Rubin's assistant, it appeared that the triangulation is completed as far as latitude $-10°\ 30'$. It has been found necessary, for various reasons, to suspend operations for the present; the assistants have been recalled, but Dr Rubin has not yet returned. The observations, so far as received, are almost completely reduced.

Mr J. M. Baldwin, a research student in Astronomy from Melbourne University, arrived at the Observatory on July 18 for a six months' course of study in practical Astronomy. Since his arrival he has devoted himself to the study of the system of α Centauri, both visually and spectroscopically, and has assisted in the general work of the Heliometer and the Victoria Telescope.

On the 20th February 1907 Sir David Gill will retire after

completing his twenty-eighth year of service as His Majesty's Astronomer at the Cape. Mr S. S. Hough, Chief Assistant, has been nominated by the Lords Commissioners of the Admiralty as his successor.

Royal Observatory, Edinburgh.
(*Director, Prof. F. W. Dyson, Astronomer Royal for Scotland.*)

Meridian Circle.—During the year several changes have been made in the instrument. The most important of these are the substitution of a spring suspension near the pivots (as in the Greenwich altazimuth) for the old method of counterpoising, and the introduction of a recording micrometer for the transits. The new counterpoise, introduced early in the year, is quite satisfactory. The recording micrometer is only just completed, and it is too soon to speak of its performance. These and some other minor alterations, combined with unfavourable weather, have made the number of observations of zodiacal stars during the year somewhat small. The number of transits and zenith distances observed during the year is 900.

15-*inch Equatorial.*—The Office of Works in July built a platform round the lower part of the pillar of the instrument, to make the handling of the instrument more easy and comfortable. The illuminations of the micrometer and circles have been rearranged, and the instrument got into adjustment for observations of double stars. Only a few observations have as yet been secured.

Spectroscopic Observation of the Rotation of the Sun.—All favourable occasions have been utilised, and 677 sets of observations made on 67 days. A few measurements have also been made of the distances of the solar lines from the telluric standards near the Sun's centre, for comparison with the means obtained from similar measurements at opposite ends of a diameter.

24-*inch Reflector.*—This instrument has been arranged for photographic determinations of the position of nebulæ. Only a few photographs have as yet been obtained; and although it will probably be impossible to obtain many photographs, it is hoped to put the instrument to this work.

Catalogue of Zodiacal Stars.—The observations have been reduced to 1900·0 as far as 1906 February, and a manuscript catalogue forwarded to Sir D. Gill. In the task of overtaking the arrears of reduction, assistance received from the Government Grant Committee of the Royal Society is gratefully acknowledged. The observations for 1906 are reduced to mean place 1906·0.

Henderson's Catalogue for 1840, re-reduced by Dr Halm, has been published during the year.

Seismographic observations have been made continuously by Mr Heath, and the results communicated to the Committee of the British Association.

Meteorological observations have been regularly made.

Cambridge Observatory. (*Director, Sir R. S. Ball.*)

1. *Meridian Circle.*—The revision and completion for press of the large volume of meridian circle results, 1872–1900, mentioned in last year's report, was finished in September, and application for printing has been made to the Syndics of the University Press. In the course of revision at the meridian circle of all the single observation stars published in the Cambridge A.G. Zone Catalogue, it happened in a considerable number of cases that the star, of which a single observation appeared in the Zone Catalogue, could not be found in the place assigned to it. The question then arose, Was the original observation erroneous, or did it refer to a very faint star only visible in the instrument on exceptional nights? With great kindness, Professor Turner undertook to examine all these doubtful cases on the Astrographic Catalogue plates taken at Oxford which cover the Cambridge zone. Very nearly all the difficulties have thus been cleared up, and the Cambridge Catalogue has derived great advantage from this final revision by the aid of the Oxford photographs.

Towards the end of the year the observation of Gill's Zodiacal Stars was resumed, and 280 stars were observed on 9 nights, with the necessary observations of fundamental stars and instrumental errors. The reductions to mean place are nearly complete to date.

Mr Hartley has been in charge of the meridian circle throughout the year.

2. *Sheepshanks Equatorial.*—One hundred and twenty-seven plates, each containing four or more exposures, have been taken by Mr Hinks during the year, the greater part of them in continuation of the series for the determination of stellar parallax begun in 1904. The observation of the fainter stars of the working list then adopted is practically complete, and the results for 10 stars are reduced and published by Mr Russell (*M. N.*, 1905 June, 1906 December). The observation of the brighter stars was interrupted by the failure of the special colour screen after a considerable number of plates had been taken. A new form of screen was constructed in experimental form in April, and the observation of bright stars has now been resumed. The finished apparatus will be mounted early in 1907.

An extensive new working list of stars has been prepared, and is incorporated with the old as vacancies occur. Observations of these stars were begun in April.

Mr F. J. M. Stratton (Isaac Newton Student) has been occupied with an investigation of the proper motions of faint stars in the Pleiades by comparison of early plates taken at Greenwich and Oxford (kindly lent by the Astronomer Royal and the Director of the Oxford University Observatory) with recent plates taken with the Sheepshanks telescope.

Mr Stratton has also undertaken a new reduction of Schlüter's observations of the Moon for comparison with Hayn's determination

of the constants of the Moon's libration and of the selenographical co-ordinates of Mösting A.

Mr H. N. Russell has continued, at Princeton, U.S.A., the measurement and reduction of plates of the stellar parallax series.

3. *Floating Zenith Telescope.* — Mr Cookson has continued throughout the year his observations with his floating zenith telescope. The climate is very unfavourable to the class of observation required for a determination of the aberration constant, and it has been found impossible to gather enough material in one year. The observations have therefore been extended over another year, and it is expected that the two years together will provide the necessary observations.

4. *Reduction of Eros Photographs.*—The formation of a homogeneous system of comparison star places has made good progress and is approaching completion.

An account of the results of intercomparison of published series from different observatories has been published during the year (*M. N.*, 1906 June, November). This showed the necessity of supplementing the published material with more complete detail, in which the results from individual plates are kept separate. By the courtesy of the Directors concerned, a great part of the required information has been obtained.

The individual observations have been collected in a card catalogue of about 18,000 cards and 50,000 entries. Systematic corrections have been determined and applied (1) to reduce all the observations to the same system of fundamental stars, and (2) to eliminate the very serious errors in the form of magnitude equation which affect the results of several observatories.

Charts of all available stars have been furnished to the Lick Observatory, and the comparison stars for the reduction of the Crossley Reflector photographs have been selected from them. Closely approximate places of the selected stars have been communicated to Professor C. D. Perrine, in advance of the definitive formation of the system.

One of the principal objects in the formation of the close standard system of stars—to provide for the reduction of the very numerous Crossley reflector plates with small measurable field—is thus in a fair way to be accomplished. The same system will be available for all other series in which it is not possible or desirable to use the *étoiles de repère* as standards—*e.g.* the Oxford and Cambridge series—and will also supply the places of a great part of the stars used as comparison stars by the visual observers. A considerable number, however, of the visual comparison stars used at Lick, Yerkes, and Washington were too faint to be found on the photographs hitherto measured and published. The places of all these stars were marked on the charts supplied to Lick, and most of them have been identified and measured on the Crossley plates. This makes good a serious deficiency in the preparations for a general reduction of all Eros observations.

Mr Hinks has been aided in this work throughout the year by

Miss Julia Bell, and since April Mr S. E. Bowd has been engaged upon the card catalogue. The expense of this assistance has been defrayed by a grant from the Government Grant Fund of the Royal Society.

5. *Instruction.*—Courses of instruction in practical astronomy, and in field astronomy and surveying, have been given by Mr Hinks during the year.

The Newall Telescope, Cambridge Observatory.
(*Mr H. F. Newall.*)

The past year, 1906, was spent, so far as new observational work is concerned, in making spectroscopic observations of the Sun. The work was mainly directed to deciding, by observations of sun-spot spectra and other solar features, whether the conditions of atmosphere over the flat plains of Cambridgeshire would justify a special outfit for solar work.

In the first half of the year the 25-inch equatorial was used with a diffraction spectrograph attached to it. In the latter half a fixed horizontal telescope was improvised by dismounting the 25-inch object-glass and fixing it in a stout wooden frame, with its axis horizontal, at a height of about 6 feet above the ground. Sunlight was directed into it by means of a cœlostat and an auxiliary mirror. The Sun's image was examined with a very powerful grating spectroscope.

The result of the trials is completely decisive. Observations with the equatorial equipment prove that good conditions of observing are available between 6 and 9 a.m. Observations with the horizontal equipment show that these conditions are not seriously impaired by bringing the beam nearer to the ground.

A short account of the observations and of some of the more readily derivable results has been communicated to the Society (*M. N.*, current volume, p. 158).

A permanent horizontal equipment for solar work is now in process of construction; the expense of it is to be met by an appropriation from the McClean bequest. The new grating spectroscope of Littrow form, with collimator-camera 14 feet long, was set up in position in the north annex on December 21.

The measurement and reduction of stellar spectra has been carried on during the year.

Bryan Cookson, M.A., Trinity College, has been appointed Assistant in Astrophysics, a new post with this title having been recently created.

Mr J. B. Hubrecht, research student in astrophysics, is investigating the rotation of the Sun by a spectroscopic method.

Mr W. H. Manning assists in the stellar work, and Mr L. J. Stanley in the solar work.

Dunsink Observatory.
(*Director, Prof. E. T. Whittaker, Royal Astronomer of Ireland.*)

Professor C. J. Joly, who had held the office of Royal Astronomer of Ireland since 1897, died in January. Mr E. T. Whittaker was appointed his successor, the appointment dating from July 1; during the first half of the year the observatory was in the charge of Mr C. Martin, Assistant Astronomer.

Mr. J. W. Vice entered into residence adjoining the observatory in September as a student of Practical Astronomy, under a scheme sanctioned by the Board of the University of Dublin.

The chief work of the year has consisted in the observation and reduction of the stars in the list of red stars—a work which was commenced by the late Director shortly before his death. The observations, which were made with the Pistor and Martins meridian circle, are now practically completed, and the work of reduction is in a forward state.

The time service to Dublin has been continued as in previous years.

The mirror of the Roberts photographic reflector was resilvered at the observatory at the beginning of December, but weather conditions prevented the use of this instrument during the rest of the month.

The professorial courses of lectures delivered in Dublin by the Director have been entitled "Theory of Optical Instruments" and "Theory of Energy and Radiation." Demonstrations in Practical Astronomy are given at the observatory by the Assistant Astronomer, and the South Equatorial has been employed on the first Saturday in each month in showing objects of interest to visitors.

Glasgow Observatory. (*Director, Prof. L. Becker.*)

The Director and his assistant were principally occupied during the year with the reductions of observations obtained in former years. A paper entitled "The distribution of blue and violet light in the Corona on 1905 August 30, as derived from photographs taken at Kalaa-es-Senam, Tunisia," has been accepted for publication by the Joint Permanent Eclipse Committee (of the Royal Society and Royal Astronomical Society).

The spectroscope attached to the 20-inch reflector was used on 19 nights in the first quarter of the year. The observations were then discontinued, as some necessary alterations had to be effected. The efficiency of the apparatus has been enhanced by a new film-holder, which, being curved to the focal surface of the camera, makes it possible to photograph with perfect definition the spectrum between wave-lengths 6000 and 3200. The film-holder is mounted on a micrometer slide, and its position can be adjusted on a spectral line.

The observations of stars close to the pole were taken up again after a year's interruption.

The scheme for the removal of the observatory has not yet taken definite shape.

The time service and the meteorological observations have been carried on as in former years.

Liverpool Observatory. (*Director, Mr W. E. Plummer.*)

The equatorial has been used mainly for the observation of comets, a class of observation with which this observatory has become identified. The observations, fully reduced up to the middle of the year, have been communicated to the Society and printed in their Journals. The observations of double stars have also been continued. During the last year some systematic inquiries have been made with the view of detecting, if possible, the effect of aperture and focal length on the measures. For this purpose attempts have been made to determine the orbits of some of the longer known binaries from observations, limited as closely as possible to the same aperture. It was thought that some of the variations from theory might be explained as due to the employment of larger telescopes than formerly. This work is still in progress.

In other departments there has been no alteration during the year. The meteorological and seismological observations are continuously maintained. Seismograms of the more remarkable earthquakes have been forwarded to the authorities who are discussing particular effects. The testing and rating of chronometers and the examination of other apparatus forms part of the routine work of the observatory. Lectures, in connection with the University of Liverpool, are regularly given in the observatory.

Radcliffe Observatory, Oxford.
(*Director, Dr A. A. Rambaut, Radcliffe Observer.*)

The principal astronomical work of this observatory during the year 1906 has consisted of investigations of stellar parallax carried on with the 24-inch photographic equatorial according to the method advocated by Professor J. C. Kapteyn (*Bulletin de la Carte du Ciel*, tome i. p. 262). It will be remembered that his method requires that a plate should be exposed at least three times to the same group of stars at about the epochs of maximum parallactic effect, the pointing of the telescope being slightly different on the three occasions, and the relative parallaxes of all the stars on the plate are deduced from measures of the distances between the images of each star so obtained.

The plates employed for this purpose at the Radcliffe Observatory are of the same size as those used in the astrographic telescopes,

viz. 160 mm. × 160 mm., but on account of the greater focal length of the Oxford telescope (22 ft. 6 in.) they cover only one-quarter of the area of the sky taken in by the former. Exposures are given of such a length as will in each case bring up at least 100 stars on the plate.

The regions observed this year have for guiding stars which are approximately central the following objects :—

B.D. No.	Description.	Yale No.	R.A. 1905·0.	N.P.D. 1905·0.	Mag.	No. of Plates exposed for 1 season.	2 seasons.	3 seasons.
			h m s	° ′ ″				
+25°, 495	Lal. 5761	40	3 2 49·97	64 0 43·7	7·9	5	5	5
...	Nova Persei	42	3 24 44·30	46 25 14·6	...	5	5	...
+41, 750	Lal. 6888-9 pr.	44	3 40 32·63	48 50 10·0	8·2	2	1	1
+15, 651	In Hyades	...	4 29 10·01	74 41 33·1	8·5	4	4	...
+51, 1094	Gr. 990	51	5 30 47·39	38 36 56·5	7·9	6	6	4
+44, 1408	...	...	6 9 55·05	45 15 16·6	8·4	8	8	5
+40, 1758	...	...	6 49 51·08	49 47 32·3	8·6	7	7	4
+48, 1469	Lal. 13,427	57	6 54 22·86	41 28 38·7	8·2	3	3	3
+31, 1684	Lal. 15,290	61	7 47 29·02	59 6 5·4	8·2	8	8	3

Six of these objects are included in the list of stars whose parallaxes have been determined with the Yale heliometer (*Transactions of the Astronomical Observatory of Yale University*, pt. ii., vol. i. p. 196). Their numbers in that list are given in the third column of the above table. To this list of objects should be added 61 Cygni, which has been included in the Oxford programme as much for the sake of affording a check on the accuracy of the methods adopted as for the purpose of obtaining a fresh value to add to the already numerous determinations of the parallax of this star.

On these objects 62 plates have been exposed during the year, representing 313 exposures. All photographs were taken near the meridian, and as near the epochs of maximum parallax factor as possible. These two conditions necessitated the taking of the observations at one season (January to April) in the early evening, and at the other (September to December) in the early morning, hours.

The last three columns of the table, showing the number of plates exposed at one, two, or three seasons, exhibit the state of this work at present.

Arrangements are now being made to bring this parallax investigation to a conclusion, and to employ the 24-inch telescope in the future for determining the proper motion of faint stars down to the 14th magnitude, in accordance with Professor Kapteyn's scheme, entitled "Plan of Selected Areas."

A number of plates other than those taken for parallax have

been obtained in the course of the year. These include photographs of Brooks' Comet, the great Nebula in Orion, the Pleiades, Præsepe, the great Clusters in Perseus, the Globular Cluster (13 M) in Hercules, the region around the north pole, etc.

The new Radcliffe Catalogue, containing places of 1772 stars, for the epoch 1900, was published and distributed early in the year. For some years past the revision of Main's observations made with the transit circle during the years 1862–1876, and published in vols. xxii. to xxxvi. of the Radcliffe Observations, has been engaging the attention of Herr Hans Osten of Bremen, in connection with Dr Ristenpart's *Geschichte des Fixsternhimmels.* Herr Osten has voluntarily offered his services for this work, and has hitherto carried it on entirely at his own expense. At Dr Ristenpart's request, the original records have in numerous cases been examined at the Radcliffe Observatory, and many discrepancies have thus been removed. The work is now approaching completion, and it is hoped that the publication in the form of a collated catalogue of Main's results may not be much longer delayed.

The preparation of another meteorological volume has engaged the attention of the staff for a considerable part of the year. This volume, which will contain the results of observations made in the years 1900 to 1905 inclusive, is already well advanced.

Meteorological and earth temperature observations have been regularly carried on as heretofore.

University Observatory, Oxford.
(*Director, Professor H. H. Turner.*)

The energies of the staff have been almost wholly absorbed during the past year by the heavy work of proof reading, and a certain amount of revision, involved in passing two volumes of the *Astrographic Catalogue* through the press. Vol. i., containing measures of 65,750 stellar images on the 160 plates, with centres in Zone $+31^{\circ}$, has been issued to a number of observatories, and vol. ii. (66,718 images; 160 plates; Zone $+30^{\circ}$) is in the binder's hands. Vol. iii. is begun, and iv.–vii. will, it is hoped, follow at the rate of two per year; vol. viii. being reserved for discussions, etc.

Temple Observatory, Rugby. (*Director, G. M. Seabroke.*)

The principal object in the erection of this observatory was the giving of a taste for astronomy in the school, and its use for that purpose increases, and not much time is left for other work. A few measures of double-stars have, however, been made. On cloudy evenings boys are taught to read verniers, to set the transit and equatorial, and to take transits and measure double-stars, using artificial stars for these purposes.

Solar Physics Observatory, South Kensington.
(Director, Sir Norman Lockyer, K.C.B.)

Observations of Sun-spot Spectra.—The Sun was seen on 253 days during 1906, and observations of Sun-spot spectra were made on 122 days, permitting the examination of 225 spots in the region F–D. The records continue to indicate that the lines affected are due to Vanadium, Titanium, Scandium, and some unknown element or elements. Daily photographs (glass negatives) of the Sun's disc are received from Dehra Dûn (India) and Mauritius, the gaps in the Indian record being filled up as far as possible by negatives from Mauritius and Greenwich. The negatives are forwarded to Greenwich for measurement and reduction as they are required. Positives on paper are also received; these are mounted on cartridge paper and bound up into half-yearly volumes for ready reference.

Spectro-heliograph.—The weather conditions were somewhat better than during 1905, being fine enough on 162 days to warrant attempts being made to obtain monochromatic photographs of the Sun in "K" light. The instrument cannot be used satisfactorily during the winter months on account of its position among high buildings. During the period 1906 January 27 to December 1 390 negatives were secured, showing the distribution of "K" radiation on the Sun's disc; with the addition of an occulting disc over the primary slit plate, 95 negatives were obtained, showing the prominences round the solar limb.

By arrangement with the Indian authorities, photographs taken with the spectro-heliographs at South Kensington and Kodaikánal are exchanged, so that the records may be as complete as possible for the year.

Stellar Spectra.—The weather conditions for night observations have been extremely unfavourable during the greater part of the year. The new mounting of the 6-inch Henry prismatic camera has been a great improvement, and the disturbances showing as declination steps appear to have been eliminated. Forty-eight photographs of nineteen stellar spectra have been obtained with the two prisms; twelve stellar spectra with the 9-inch prismatic reflector; the 2-inch quartz-calcite prismatic camera has been employed in photographing ten pairs of stellar spectra, under conditions as nearly constant as possible, for recording extensions of the continuous spectrum in relation to the positions of the stars on the temperature curve of chemical classification. With the 36-inch reflector photographs were taken of the spectrum of the Orion nebula, *o* Ceti (Mira), and *α* Orionis.

Publications.—Various papers dealing with stars of peculiar spectra, barometric variations of long duration over large areas, wave-lengths of enhanced lines, and eclipse reductions have been completed during the year, and others on allied subjects are in course of preparation.

Royal College of Science, South Kensington.
(*Assistant, Professor A. Fowler.*)

The observatory exists primarily for the instruction of students, but some of the instruments are also employed in the spectroscopic examination of Sun-spots and prominences. Solar observations were made on 100 days during the year.

Investigations of terrestrial spectra are also carried on, more particularly as regards their application to the interpretation of solar phenomena. Some of the results have been published in the *Monthly Notices* (vol. lxvi. No. 6), and in the *Transactions of the International Solar Union* (vol. i.).

Stonyhurst College Observatory, Astrophysical Department.
(*Director, Rev. W. Sidgreaves.*)

The solar surface has been under observation on all available days during the year, and 210 drawings of spots and faculæ have been made.

The large grating spectrometer has also been employed upon the larger spots when the atmosphere has been calm enough for the steady working of the present heliostat.

A new heliostat is being built for the observatory by Sir Howard Grubb, through favour of the Royal Society's Government Grant Committee. This will carry a 12-inch silver-on-glass reflector, on loan to the observatory by the British Astronomical Association; and the system will be completed by a second reflector of 16 inches diameter, lent by the Royal Astronomical Society.

With this addition the full aperture of the 8-inch objective of the old equatorial telescope will take the place of the present half-filled 4-inch lens, and is expected to add very greatly to the efficient working of the large Rowland grating on the solar surface.

The 4-inch prismatic camera has been employed on almost every available night, but only on a selected number of the brighter stars which had been suspected of showing variable spectra.

Some very good photo-spectrographs of *Mira Ceti* were obtained between November 25 and January 3, both by the Hilger compound prism adapted to the great equatorial, and by the Thorp objective prism on the Cook 4-inch Finder, now mounted as a separate equatorial telescope. But the hopeless clouds and fogs of January have shut out all possibility of following the star's spectrum through the conditions of its declining light.

Wolsingham Observatory. (*Rev. T. E. Espin.*)

The work of measuring with the micrometer neglected double stars, more especially those of Sir John Herschel, has been continued in the past year, and the results presented to the Society. During the year 134 new pairs have been detected and measured. Observations were made on 70 nights during the year.

Sir William Huggins's Observatory, Upper Tulse Hill.

The photography of the spectra of stars and of other celestial bodies, which has been in progress for many years, is being continued.

Experimental work in the laboratory has included further experiments on the radiation of radium, of which some of the results have appeared in the *Proceedings of the Royal Society.*

Sir Wilfrid Peek's Observatory, Rousdon, Lyme Regis.
(C. Grover, Observer in Charge.)

The observatory and astronomical instruments are in good working order. Weather was favourable, and observations were made on 148 nights during the year 1906. Observations of the long-period variable stars have been continued on Argelander's method, and 407 magnitude determinations were made; 18 maxima and 4 minima have been recorded. During the twenty-one years this work has been in progress 9707 magnitude determinations have been made, and 379 maxima and 288 minima have been recorded.

Several of the comets of the year were observed; they were mostly very faint and of little interest.

The planet Saturn was favourably placed during the autumn; and September being remarkably fine, with twenty-three nights' observation, the smaller satellites were better seen than usual, and several interesting configurations were observed.

The minor planet Vesta was observed on several nights in November. It was easily seen with a binocular glass, and its motion followed from night to night in the vicinity of the well-known double star 94 Aquarii.

Transits of stars for regulating the sidereal clock were mostly taken during daylight.

Mr Saunder's Observatory, Crowthorne, Berks.

The measures of 1800 points on a Yerkes negative of the Moon taken 1901 November have been completed. About a quarter of the work of reduction has been accomplished. Rather more than 1500 points have been partly measured on another Yerkes negative taken 1901 August. Of these, 400 have been completely measured, the plate constants have been determined, and about 100 points have been completely reduced. The constants of both these plates have been determined by Professor Turner's method (*M. N.*, vol. lx. pp. 202–205), and the probable errors indicate that a satisfactory degree of accuracy has been attained.

Dr W. E. Wilson's Observatory, Daramona, Co. Westmeath.

The long period of cloudy, wet weather seems to hold. Rain fell on 251 days, giving a total of 35·80 inches. Practically no work was done in the observatory. The experiments were continued with the new instrument, which has been named a Radio-Integrator. This simple instrument gives the daily amount of the vertical component of solar radiation in calories. It has been adopted at Kew, Falmouth, Aberdeen, and Valentia.

Kodaikánal and Madras Observatories.
(*Director, C. Michie Smith.*)

The first five months of the year were, on the whole, favourable for solar observations, but the remainder of the year was decidedly unfavourable. There were 26 days in the year on which no observations were possible.

Photoheliograms were taken on 317 days, and approximate positions of spots were obtained by projection or by eye observations on 339 days. Up to the end of November it was found possible to send to Greenwich all the solar negatives required to fill in the gaps in the Greenwich and Dehra Dûn set of daily photographs. In all, 297 new groups of spots were recorded during the year. The mean daily number of groups visible varied from 1·8 in October to 7·2 in July, and the average for the year was 4·4.

Spectroscopic work.—Observations of spot spectra were made on 181 days, and prominences were recorded on 269 days. It has not yet been possible to begin photographic work on sun-spot spectra, but as Mr Evershed is expected to join the staff early in 1907, this defect should soon be remedied. The necessary apparatus is available, and the only difficulty is to find the time required for the work.

Spectroheliograph.—Photographs with the spectroheliograph were taken on 277 days. The total number of plates taken was 1163, but of these a considerable number had to be rejected for various reasons. Most of the failures were due to attempts to obtain photographs through clouds or in short breaks, a few were due to bad setting, and a few to defective plates. The instrument has worked admirably during the year, and a large number of excellent photographs both of flocculi and prominences have been obtained. Trouble from unsteadiness of the air has, of course, continued, but it has been considerably reduced, and it is hoped that when the new building for the siderostat, now under construction, is completed, still less trouble will be experienced from this source.

Publications.—Bulletins Nos. iv. to vii. were published during the year, and No. viii. was in type at the close of the year.

At Madras, astronomical observations were confined to those necessary for the time service, which was efficiently maintained. A new Riefler clock has come into use, and has been found most satisfactory.

Perth Observatory, Western Australia.
(Director, Mr W. Ernest Cooke.)

Astrographic.—During the year, 167 plates were taken and passed as satisfactory. In addition, 21 plates have been exposed but not yet developed, owing to the destruction of the réseau, either by growth or chemical action, first noticed on 1906 December 7. A new réseau has been ordered, and upon its arrival the plates which have been already exposed in the telescope will be completed.

There are now only 101 regions to be photographed, and these will probably be finished by July.

No provision has yet been made for measuring the plates, but rearrangements of some kind will probably be made shortly, owing to the creation of a Federal Weather Bureau, and it is hoped that the pressing need for this work will then be recognised by the Government.

Transit Circle.—The whole year has been devoted to the observation and reduction of the 420 secondary standards which are to be used as fundamental stars for the zones 31°–41° S. declination. The observations are completed, and the catalogue will be ready for the printer in a few days. A minimum of 10 complete determinations of nearly all the stars has been secured, and the catalogue, it is hoped, will be printed and distributed very shortly. The following is the result of the year's work in tabular form :—

Nights on which time was determined		210
Observations of secondary standards in R.A.		2718
,, ,, ,, N.P.D.		2728
Observations of clock stars in R.A.		991
Separate determinations of	Collimation error	25
	Level	254
	Azimuth	167
	Nadir point	118
Readings of meridian mark		136

Meteorological.—The usual meteorological work was continued, and the annual report for 1905 printed and distributed. The new method of issuing forecasts has proved very successful.

The Federal Parliament authorised the creation of a Federal Weather Bureau, and Mr H. A. Hunt, of the Sydney Observatory, has been appointed Federal Meteorologist. The bureau will probably come into operation during the present year.

Sydney Observatory. (Acting Director, Mr H. A. Lenehan.)

Early in January 1906 Dr Alberto Alessio, Navigating Lieutenant of His Italian Majesty's ship *Calabria*, visited Sydney, and at this observatory, in the same position as used by previous observers, undertook a series of gravity determinations whilst his ship remained in port. At the Red Hill Branch Observatory he took magnetic observations on the same stand as that used by

Dr Hecker of Potsdam in the year 1904. The computations are not reduced yet, but Dr Alessio has hopes that they will compare favourably with those of previous observers.

Another officer, connected with the Carnegie Scientific Investigations, Mr G. Heimbrod, visited Australia in November 1906 for magnetic determinations, and has, in N. S. Wales, used the same position and pier at the Red Hill Branch of the Sydney Observatory, so that he may be able to verify the previous computations.

As stated in the last report, it was found necessary to remove the magnetic instruments out of the influence of the electric energy now so much used for municipal lighting and the tramway service. The magnetic work is now done at the Red Hill Branch by Mr Short, the astronomical photographer, in addition to his duties in astrophotography.

The mechanician, Mr W. I. Masters, has, as opportunity occurred, practically remade some of the instruments in use for many years. The tape chronograph, procured prior to 1865, and which had 88 lbs. to drive it, is now a new instrument, and is driven by 30 lbs. The whole of the working instruments, which are to a certain extent obsolete, are on the list to be renewed when the time can be devoted to them.

The equatorial has not been in regular commission during the year, as some adjustments require to be made.

The seismograph, which had been dismantled owing to the effects of the heavy blasting operations by the Sydney Harbour Trust, was not again put into commission till May 17. The record of the San Francisco earthquake of April 18 was therefore lost.

The buildings of the observatory have been renovated throughout and two new rooms added. This will overcome the congestion in some of the offices caused by the accumulation of many years' meteorological records, which, under the old conditions, for want of space, had to be stacked on the floors of the rooms.

With regard to the future of the observatory, the Commonwealth Government has decided to deal with meteorology only, leaving the astronomical work with the State Government. The future arrangements for its control are still uncertain, and it is not yet decided whether the observatory will remain in the same building or be sent to the clearer atmosphere of Pennant Hills, where the astrographic work is at present carried on.

The astronomical assistants, Messrs Raymond and Merfield, have observed during the year with the transit circle, and the results are as under:—

Number of R.A. observations of stars . . .	2495
„ N.P.D. „ . . .	2124
„ R.A. „ of Sun . . .	455
—making a total of R.A. observations . .	2950

The 9 A.M. collimation, level, and nadir observations 308 of each.
The 9 P.M. level and nadir observations . . . 147 „
Azimuths determined from 137 pairs of circumpolar stars.

The year 1906 has been particularly favourable for observations, a greater number of stars having been observed than for a good many years past. The greater bulk of the observations were made during the winter months, when the definition was first-class. The 1905 Catalogue has been prepared, checked by the junior computers, and only the abstract remains to be made to finally complete it. In addition, the R.A.'s and N.P.D.'s of nearly all the observations made during 1906 have been checked, and the 1906 Catalogue will be put in hand at once.

1605 visitors have registered their names during the year. Of this number, 710 attended the evening lectures with the equatorial and lantern.

The astrographic work at the Red Hill Branch has been carried on by astronomical photographer Mr J. W. Short, who, in addition, has charge of the magnetic work. The magnetic instrument, an old one, has been compared with the modern instrument at the Melbourne Observatory, and, owing to the report received, it has been decided to get a set of new magnets. The Director of the Kew (England) Observatory has been asked to obtain these, and to certify to the errors, etc. before he accepts them. It is hoped that they will be received by April next.

Owing to the instrument being away part of the year in Melbourne the magnetic observations were incomplete, but the declination and dip remain practically constant.

Plates exposed.—Catalogue plates, 31; chart plates, 137. Total number of plates used, 175.

Photographs were also taken of the occultation of *Saturn* in October.

Many of the plates taken have been sent to Melbourne to be measured by the Joint Measuring Bureau (Sydney and Melbourne).

The number of fine nights was 115, partially fine 120, and the remainder cloudy and wet.

Library.—Mr Graham reports that the library received, by way of exchange from other observatories and institutions, 1050 books, pamphlets, and papers, being an increase over that of 1905 by 5 per cent.

The publications distributed were very few—only 200. This is due to the discontinuance of the publishing of the annual rain and meteorological reports. The distributions compare very unfavourably with those of the year 1905, when 2932 books were sent out.

The library is being gradually put into proper order, and a catalogue formed.

Lovedale Observatory, South Africa.
(*Dr Alex. W. Roberts.*)

Observations were made only during the months of January and February. During the greater part of the year the Director was in England, and advantage was taken of the opportunity to have

the observations made since 1891 reduced. This work, which is now nearly completed, was facilitated by a grant from the South African Association for the Advancement of Science, to whom, as well as to Sir David Gill, the Director wishes to express his acknowledgments.

Mr Tebbutt's Observatory, Windsor, New South Wales.

For the reasons stated in the Annual Report of the Observatory for 1903, regular observations were discontinued at the close of that year. There is, therefore, little to record for the year 1906. The only astronomical observations made were some measures of the well-known binary *p Eridani* and observations of the lunar occultation of *Saturn* and *Titan* on 1906 October 27. These observations have all been sent to the Society for publication. The usual meteorological observations were also taken.

Notes on some Points connected with the Progress of Astronomy during the Past Year.

Discovery of Minor Planets in 1906.

One hundred and seventeen new planets were discovered or first announced in 1906, as follows:—

Letter and Number.	Date of Discovery.	Discoverer.	Letter and Number.	Date of Discovery.	Discoverer.	Letter and Number.	Date of Discovery.	Discoverer.
SJ ...	Jan. 15	K	HV[a] ...	Mar. 5 (02)	W	US ...	Aug. 22	W
SL ...	22	W	SD[a] ...	Nov. 3 (05)	Ly	UT ...	22	K
SM ...	22	W	TP 591	Mar. 14	K	UU ...	27	W
SN ...	22	W	TQ ...	17	W	UV ...	28	K
SO 582	23	K	TR ...	17	W	UX ...	Sept. 12	K
SR ...	24	W	TS 592	18	W	UY ...	12	K
SS ...	24	W	TT 593	20	K	VA ...	17	K
ST ...	24	W	TU ...	20	W	VB ...	18	K
SU ...	24	W	TV ...	21	W	VC ...	18	K
SV ...	24	W	TW 594	27	W	VD ...	18	K
SW ...	24	W	TX ...	27	W	VE ...	15	M
SY 584	15	K	TY ...	27	W	VF ...	24	W
SZ ...	Feb. 16	W	TY[a] ...	Mar. 27	W	VG ...	24	W
TA 585	16	K	TZ 595	27	W	VH ...	24	W
TB ...	16	W	UA 596	Feb. 21	W	VJ ...	26	K
TC 586	21	W	OO[a]	Aug. 12 (04)	G	VK ...	26	W
TD ...	21	W	UB 597	Apr. 16	W	VL ...	24	M
TE ...	16	M	UC 598	13	W	VM ...	24	M
TF 587	22	W	UJ 599	25	M	VN ...	Oct. 8	K
TG 588	22	W	UK ...	May 13	W	VO ...	8	K
TH ...	22	W	UL ...	29	W	VP ...	11	K
TJ ...	16	M	UM 600	June 14	M	VQ ...	11	K
TK ...	16	M	UN 601	21	W	VR ...	11	K
TL ...	22	M	UO ...	July 30	W	VS ...	11	K
TM 589	Mar. 3	K	UP ...	Aug. 13	K	VT ...	8	L
TN ...	3	W	UQ ...	22	W	VU ...	17	K
TO 590	4	W	UR ...	22	W	VV ...	17	K

Letter and Number.	Date of Discovery.	Discoverer.	Letter and Number.	Date of Discovery.	Discoverer.	Letter and Number.	Date of Discovery.	Discoverer.
VW ...	Oct. 17	K	WJ ...	Nov. 11	K	WW...	Dec. 20	K
VX ...	17	K	WK ...	11	K	WX ...	21	K
VY ...	17	K	WL ...	11	K	WY ...	22	L
VZ ...	17	L	WM...	10	K	WZ ...	22	L
WA ...	21	W	WN ...	14	L	XA ...	21	K
WB ...	22	W	WO ...	12	M	XB ...	21	K
WC ...	22	K	WP ...	13	M	XC ...	21	K
WD ...	13	L	WR ...	14	M	XD ...	23	K
WE ...	26	M	WS ...	14	M	XE ...	18	K
WF ...	Nov. 9	K	WT ...	19	M	XF ...	18	M
WG ...	9	K	WU ...	Dec. 7	M	XG ...	18	M
WH ...	11	K	WV ...	7	M	XH ...	18	M

The year of discovery is 1906 unless otherwise noted; the abbreviations (02) (04) (05) stand for 1902, 1904, 1905. The initials represent G, Götz; K, Kopff; Ly, Loewy; L, Lohnert; M, Metcalf; W, Wolf. All the discoveries were made at Heidelberg, except those by M. Loewy (at Paris) and Dr Metcalf; the latter gentleman's observatory is at Taunton, Mass., U.S.A., and he has adopted the method of guiding the telescope so as to move at the rate of an average minor planet moving parallel to the ecliptic. In this way fainter planets can be photographed, since their trails are much shorter. Planets are distinguished from photographic defects by two exposures, with a shift in declination between them.

The following planets not numbered at the date of the last report have since received permanent numbers: QX 570, QZ 571, RB 572, RC 573, RD 574, RE 575, RF 576, RH 577, RZ 578, SD 579, SE 580, SH 581, SP 583.

The following errata in the last report (vol. lxvi. p. 217) may be pointed out:—RT, *not* RN, is identical with 477 Italia; HB, *not* HA, is identical with 526 Jena; *for* Oello, Genna, *read* Ocllo, Genua.

The following planets do not receive permanent numbers, not having been sufficiently observed:—RG, RJ, RL, RM, RN, RO, RP, RQ, RR, RS, RU, RV, RW, RX, RY, SA, SB, SC, SD^2, SG, SJ, SL, SM, SN, SR, SS, ST, SU, SV, SW, SZ, TB, TD, TE, TH, TI, TK, TL, TN, TQ, TR, TU, TV, TX, TY, TY^2, UK, UL, UO, UP, UQ, UR, US.

The following identities have been established:—CR (possibly) 488, CX 554, KR = KV, KY 529, SF 488, SK 275, SQ 411, SX 88, UD 181, UE 410, UF 394, UG 149, UH 431, UW 66, UZ 408, WQ 167, 469 = 488; the number 469 has been transferred to GE (discovered 1901).

The following planets have been named:—400 *Ducrosa*, 459

Signe, 461 *Saskia*, 463 *Lola*, 464 *Megaira*, 465 *Alekto*, 466 *Tisiphone*, 467 *Laura*, 468 *Lina*, 469 *Argentina*, 471 *Papagena*, 473 *Nolli*, 474 *Prudentia*, 479 *Caprera*, 480 *Hansa*, 481 *Emita*, 490 *Veritas*, 492 *Gismonda*, 495 *Eulalia*, 500 *Selinur*, 501 *Urhixidur*, 502 *Sigune*, 513 *Centesima*, 514 *Armida*, 515 *Athalia*, 524 *Fidelis*, 525 *Adelaide*, 526 *Jena*, 527 *Euryanthe*, 528 *Rezia*, 529 *Preciosa*, 530 *Turandot*, 531 *Zerlina*, 536 *Merapi*, 538 *Friederike*, 539 *Pamina*, 540 *Rosamunde*, 541 *Deborah*, 543 *Charlotte*, 545 *Messalina*, 546 *Herodias*, 547 *Praxedis*, 548 *Kressida*, 549 *Jessonda*, 550 *Senta*, 551 *Ortrud*, 552 *Sigelinde*, 553 *Kundry*, 555 *Norma*, 556 *Phyllis*, 557 *Violetta*, 558 *Carmen*, 559 *Nanon*, 560 *Delila*, 561 *Ingwelde*, 562 *Salome*, 563 *Suleika*, 564 *Dudu*, 567 *Eleutheria*, 581 *Tauntonia*.

The interesting planets *Thule* and *Andromache* were photographed at Heidelberg, also 294 *Felicia*, which had not been seen since 1891.

It is hardly necessary to say that 1906 breaks all records for the number of discoveries; it has, indeed, practically doubled the previous record of 59 in 1904. It is, of course, likely that a certain number of the planets described as new will be subsequently found to be old ones re-observed, but in any case the number of actual discoveries must be very large, showing that the hopes expressed a few years ago that the zone was approaching exhaustion were decidedly premature. As if to show that the search for planets cannot be abandoned without the risk of losing some very interesting objects, one of the bodies discovered last year has a very remarkable orbit. This is TG 588, which Dr Berberich has found to have a mean distance almost (perhaps exactly) the same as that of *Jupiter*, and a large eccentricity, so that its aphelion distance is 6·2, an entire astronomical unit beyond *Jupiter's* mean distance. The planet's heliocentric longitude at discovery was $55\frac{1}{2}^\circ$ greater than that of *Jupiter*, from which Dr Charlier concludes that it is very probable that the Sun, *Jupiter*, and 588 illustrate Lagrange's proposition that three masses at the angles of an equilateral triangle will, if properly projected, continue to move with unchanged relative configuration about their common centre of gravity. Since the orbits of both *Jupiter* and 588 are eccentric, and their planes inclined to each other at an angle of about 10°, the above conditions are not rigorously fulfilled; but provided certain limits are not exceeded, they could oscillate about the equilateral position as a mean. The re-observation of 588 may be expected shortly, when it will presumably be possible to ascertain whether its mean motion is the same as that of *Jupiter*, in which case Dr Charlier's hypothesis is probably correct. Dr Berberich's elements of 588 are given. Epoch 1906, Feb. 22·5, Berlin M.T., M 48° 57′ 24″, ω 120° 25′ 50″, Ω 315° 34′ 7″, i 10° 20′ 53″, ϕ 9° 38′ 43″, μ 295″·13, log a 0·71999.

The *Berliner Jahrbuch* for 1908 gives the following statistics about the observation of the minor planets up to the epoch March 1906:—388 planets had been observed at 4 or more oppositions,

31 at 3 oppositions, 53 at 2 oppositions, 97 at 1 opposition only. It is of interest to give the actual list of these lost planets from 1 to 400 inclusive:—99, 132, 155, 193, 220, 285, 290, 293, 309, 310, 315, 316, 320, 323, 330, 353, 357, 368, 392, 396, 398, 400.

A. C. D. C.

The New Satellites of Jupiter and Saturn

During the past year Dr F. E. Ross has published the following revised elements of *Jupiter* VII., referred to the Earth's equator.

Epoch. 1906 Jan. 0·0 G.M.T.

$g = 18^\circ{\cdot}9$	$e = 0{\cdot}208$
$\pi = 118^\circ$	$n = 1^\circ{\cdot}386$
$\Omega = 291^\circ$	log. $a = 8{\cdot}8946$
$i = 25^\circ\ 28'$	Period $259^d{\cdot}7$

Recent Greenwich observations seem to show that the above period is somewhat too long; probably the value 257 days is nearer the truth.

A successful search has been made on the Harvard plates for images of *Jupiter* VI. in the years preceding its discovery (*Harvard Annals*, vol. lx. No. 11). The following positions are given:—

Date.	Satellite—*Jupiter* R.A.	Dec.
d	m s	′ ″
1894 Jan. 25·563 G.M.T.	−3 30·75	+2 51·2
1899 June 26·561 ,,	+2 54·42	+6 16·3
,, ,, 27·588 ,,	+2 56·01	+6 0·7
,, ,, 30·566 ,,	+2 59·30	+5 20·3
,, July 1·594 ,,	+3 0·20	+5 7·4
,, ,, 12·605 ,,	+2 56·38	+2 7·7

A position given for 1894 February 2 is omitted here, since it is inconsistent with that for January 25, and the identity of the object observed with the satellite seems doubtful. The chief value of the above positions will be to improve the value of the sidereal period, and possibly also the secular changes in the elements. For this purpose it will be necessary to compute the perturbations for the above dates. However, their effect divided by so many revolutions cannot be serious, and the values of the period obtained by neglecting them are probably near the truth: these are $250^d{\cdot}3$ from the 1894 position, $250^d{\cdot}5$ from the assemblage of the 1899 ones: as the recent observations appear to indicate $250^d{\cdot}7$, it is probable that the value $250^d{\cdot}5$ is within $0^d{\cdot}2$ of the truth. The periods of VI., VII. are so nearly equal that some thirty years are required for VI. to gain a revolution on VII.

Professor Pickering notes in the same number of the *Annals*

that "the tenth satellite of *Saturn*, which is an exceedingly difficult object, can be seen when within 2′ of the planet."

Astr. Nachr. No. 3143 contains an ephemeris of *Jupiter* VI. calculated by J. E. Martin, of Washington, from unpublished elements by Dr F. E. Ross, extending from 1906 August 20 to 1907 April 17. The discordances between prediction and observation are small, as is also the case with Dr Ross' ephemeris of *Phœbe*, of which numerous observations have been obtained at Arequipa during 1906.

The following table gives a summary of the *Phœbe* observations:—

Date.	Obsd.—Tab. R.A.	Obsd.—Tab. Dec.	Number of Nights.
	s	′	
1906 May 19·4	−0·3	−0·3	2
June 27·4	−0·9	0·0	4
Aug. 16·0	−0·8	−0·2	3
,, 23·8	−0·9	0·0	3
Sept. 14·6	−1·6	−0·1	3

A. C. D. C.

The Comets of 1906.

The number of comets discovered and observed during the past year has been unusually large. Some of the particulars connected with their history can be most conveniently exhibited in a table.

Comet's Designation at Discovery.	Date of Discovery.	Name of Discoverer.	Date of last known Observations.	Date of Perihelion Passage.	Comet's Catalogue Designation.
	1905.		1906.	1905.	1905.
Comet 1905 *b*	Nov. 17	Schaer.	Jan.	Oct. 25	V.
				1906.	1906.
,, 1905 *c*	Dec. 6	Giacobini.	Mar.	Jan. 22	I.
	1906.			1905.	1905.
,, 1906 *a*	Jan. 26	Brooks.	Apr.	Dec. 22	VI.
,, 1906 *b*	Mar. 3	Kopff.	May.	Oct. 18	IV.
				1906.	1906.
,, 1906 *c*	,, 17	Ross.	Apr.	Feb. 21	II.
,, 1906 *d* (Finlay)	July 16	Kopff.	Still visible.	Sept. 8	V.
,, 1906 *e*	Aug. 22	Kopff.	Oct.	May 3	IV.
,, 1906 *f* (Holmes)	,, 28	Max Wolf.	Still visible.	Mar. 14	III.
,, 1906 *g*	Nov. 11	Thiele.	,,	Nov. 21	VII.
,, 1906 *h*	,, 14	Metcalf.	,,	Oct. 11	VI.

Necessarily, the orbits are not yet definitive, so that the catalogued order cannot be regarded as finally settled. Subsequent discoveries may further disturb the designation. But the divergences from the order of discovery are sufficiently remarkable, and must not be overlooked.

The first two comets on the list were mentioned in the last Annual Report. Comet 1905 V. calls for no further remark. As anticipated, comet 1906 I. was observed at the Cape of Good Hope, and subsequently at other observatories in Europe and America.

Comet 1905 VI. is of the ordinary parabolic class, and possesses no points of interest.

Comet 1905 IV. was actually photographed at the Königstuhl Observatory on 1905 January 14, or 413 days earlier than Dr Kopff's announcement. The orbit is remarkable for the large perihelion distance (3·3 R). This distance has been exceeded only in the case of the comet of 1729. The motion may be regarded as parabolic, though an ellipse of 1153 years' period has resulted from computations in which no assumption was made regarding the excentricity.

Comet 1906 II. was discovered in the southern hemisphere, and was very unfortunately situated for European observatories. The observations, few in number, extend over little more than three weeks. The elements, though uncertain, appear to be of the ordinary parabolic class. This is the more probable owing to the large inclination, the motion being nearly perpendicular to the ecliptic.

Comet 1906 V. is the third return of the comet of Finlay, which passed undetected in 1899–1900. The accumulated error in the mean anomaly in this long interval, arising from neglect of perturbations and other causes, made the ephemeris calculated by M. Fayet, from the elements of M. Schulhof, somewhat uncertain. The position with regard to our horizon is not very favourable for observation, but the opportunity these observations afford for correcting the mean motion is most fortunate, since, in the next revolution, the comet will approach (in 1910) so close to *Jupiter* as to suffer very considerable perturbations. Observations at the next return will afford very exact means for determining the mass of that planet.

Comet 1906 IV. proved to be one of the family of short-period comets. The observations did not begin till after the perihelion passage, and could not be pursued very long, but the elliptic character is well marked.

Comet 1906 III. is the second return of Holmes' Comet. A very few observations, and only with the large equatorials of the Lick and Yerkes Observatories, were obtained in 1899–1900, but Dr Zwiers found these sufficient to correct the elements, and, after allowing for the effect of perturbation by *Jupiter*, he was able to supply an ephemeris which represented the path of the comet with great accuracy. From this ephemeris Dr Max

Wolf succeeded in photographing the comet on August 28, and though the object was, and has remained, very faint, it is probably still under observation in the largest telescopes.

Comet 1906 VII. is a tolerably bright comet, still visible, whose motion can be represented by a parabola.

Comet 1906 VI. is a faint object, discovered on a photographic plate by Mr Metcalf, of Taunton, U.S.A. The observations have not been very numerous, and, like some others mentioned, have all been post-perihelion, but there is no doubt the object belongs to the family of short-period comets. The most probable period is about $7\frac{1}{2}$ years; and the elements bear a very strong resemblance to those of Faye, Wolf, and some others.

The orbits of the following comets have been definitively determined during the year:—

Comet.	Character of Orbit.	Calculator.	Authority.
1742 I.	Parabolic	B. Cohn	*Ast. Nach.* No. 4111.
1819 II.	Elliptic	Peck	*Ast. Journal*, Nos. 584–5
1826 V.	Parabolic (?)	Hnatek	*Denksch. Wien Ak.* 77
1844 III.	Elliptic	Fayet	*Thèses, Paris*, 1906
1864 III.	Elliptic	Schroeter	*Ges. d. Wiss. Christ.* 1905
1874 II.	Parabolic	Burggraf	*Sitzb. Wien Ak.* 1904
1883 I.	Hyperbolic	Hellebrand	*Ast. Nach.* No. 4090

The result of the calculation in the case of 1826 V. is not very satisfactory, since some of the outstanding residuals are large. 1844 III., according to Bond's calculations (*Ast. Journal*, 103), gave marked evidence of hyperbolic motion. Fayet's new reduction of the observations does not confirm this suggestion. In the case of 1883 I. a parabola would amply satisfy the observations; the hyperbola is a computational result.

W. E. P.

Progress of Meteoric Astronomy in 1906.

Meteoric observation does not appear to have made substantial progress in 1906. Observers were few, and no specially active showers attracted attention. The *Perseids* returned at a period of very unsettled weather, and the *Leonids* and *Andromedids* failed to present active appearances.

The *Böotids* (or *Quadrantids*) were visible on the early evening of January 3, furnishing some brilliant long-pathed meteors, but the display could not be closely watched at Bristol, as clouds quickly gathered over the sky.

The *Lyrids* were well observed by Mr C. L. Brook, at Melthaui,

near Huddersfield, on April 21. In $3^h\ 40^m$, between $9^h\ 20^m$ and 14^h, he counted 37 meteors, including about 20 *Lyrids*, from a radiant apparently double at $267\frac{1}{2}^\circ + 35^\circ$ to $275^\circ + 31^\circ$. The mean position at $271^\circ + 33^\circ$ agrees exactly with the best previous determinations of the shower-centre. The *Lyrids* seen by Mr Brook were quick, and a proportion of them left streaks. On April 20, during nearly an hour, only one meteor was recorded, so that the maximum appears undoubtedly to have occurred on April 21, and to have furnished some similar characteristics to the display of 1901 April 21.

The August *Perseids* returned in about average strength, but partial moonlight and stormy weather prevented much observation until August 12, 13, and 14, when a fair number of meteors were seen by Miss Irene Warner, of Horfield, Bristol, as follows:—

Aug. 10.	$9\frac{3}{4}^h$ to 11^h, 15 meteors.		Many clouds.
„ 12.	11 to 12, 16 meteors.		Partly clear.
„ 13.	30 meteors per hour.	$2/3^{rds}$ *Perseids.*	Cleared after storms.
„ 14.	20 meteors per hour.	$1/3^{rd}$ *Perseids.*	Cleared after storms.

On October 22, $10^h\ 15^m$ to $13^h\ 25^m$, Mr C. L. Brook saw 26 meteors, including several *Orionids*. At $12^h\ 16^m$ a third mag. meteor was doubly observed by Mr Brook and by Mr J. P. Kenyon at Stockport from a radiant at $98^\circ + 14^\circ$. This was an example of the *ξ Geminids*, and the latter system at the October epoch appears to have furnished a richer display than the *Orionids* in recent years.

About the middle of November a few of the usual streaking *Leonids* were remarked, and several brilliant fireballs, including *Leonids* and *Taurids*, were reported. On November 16, at $13^h\ 20^m$, what appears to have been a magnificent *Leonid* was seen at Hampstead, N.W., and Walton-on-Thames. It gave a flash like lightning and left a streak for several minutes, but the observations are not sufficiently accurate or numerous to afford useful deductions as to the real path. On the evening of November 17, between $11^h\ 9^m$ and $11^h\ 40^m$, Mr Brook registered three *slow-moving Leonids*. One of these was also noted by Mr Kenyon, and it had a velocity certainly not exceeding 30 miles per second. It is frequently found that the swifter class of meteors during horizontal flights exhibit unduly slow motion, as though encountering great atmospheric resistance. As another case of the same kind, the very long-pathed *Aquarid* observed by Professor Herschel and Mr Bridger on 1900 May 3 may be mentioned; this object had a visible flight of 155 miles and a velocity of 28 miles per second, which is much less than the theoretical speed of about 40 miles per second.

The *Leonids* were well observed by Mr C. P. Olivier, at the

Leander McCormick Observatory, University of Virginia, U.S.A., on November 16, and the following numbers were counted:

Local Time.	*Leonids.*	Others.	Total.	Remarks.
h m h m				
to 12 0	1	7	8	Clear. Leo just rising.
12 0–13 0	4	10	14	,,
13 0–14 0	9	8	17	,,
14 0–14 11	3	1	4	,,
14 36–15 0	3	3	6	,,
15 0–16 0	14	12	26	,,
16 0–17 0	14	10	24	Clouds near horizon.
17 0–17 21	4	2	6	Part cloudy.
	52	53	105	

Eight of the *Leonids* were equal to first magnitude stars. The prevailing colour was yellow, but there were many green and a few red ones. The finest meteor Mr Olivier ever observed came at $17^h\ 51^m$. It was equal to the moon at first quarter, and ended at ψ *Virginis* after a path of only 3°. From 12 meteors plotted near the radiant, the centre came out at $151° + 22°$. The streaks left by some of the meteors were very persistent, and the display was considered very good, considering its lateness. Several minor radiants were in strong activity. These details are given in *Popular Astronomy* for January 1907.

Mr Brook witnessed a fairly active return of the *Geminids* on December 12 (a few were also noticed on December 13), and bright meteors were seen on December 12, $13^h\ 35^m$, and December 13, $6^h\ 40^m$. On Dec. 12, during watches amounting to $2^h\ 42^m$, between $10^h\ 35^m$ and $13^h\ 42^m$, 51 meteors were seen (of which 26 were registered), and many others must have escaped observation.

A considerable number of fireballs and large meteors of various kinds have been reported during the year, but, except in a few instances, the descriptions were not so precise and complete that the real paths might be derived. It is to be hoped that more attention will be given to this particular branch of observation, and every effort made to secure the necessary data for ascertaining the heights, velocities, and radiants of these interesting bodies. They usually make their apparitions at times when least expected, and are often seen accidentally, but their positions and directions amongst the stars should always be registered with the utmost accuracy possible under the circumstances.

In 1906 the following real paths were computed for meteors seen in this country:—

Date.	G.M.T.	Brightness.	Height at First. Miles.	Height at End. Miles.	Length of Path. Miles.	Velocity. Miles per Sec.	Radiant Point. α δ	Observers.
1906.	h m						° °	
Jan. 27	8 33	= ☽	59	45	42	24	214+53	13
Feb. 13	10 42	♀	61	28	36	...	105+51	3
Mar. 23	10 52	½= ☽	68	45	47	...	218+10	3
April 15	8 6	3× ♀	65	28	39	18	153+33	3
16	8 53	> ♃	69	22	53	15	187+33	3
21	13 4	*Sirius*	89	56	32	25	275+35	2
Aug. 5	10 33	> ♀	65	52	24	30	38+55	3
Sept. 1	10 0	> 1	79	40	52	...	320+12	2
15	10 24	3× ♃	77	43	72	21	245+30	2
27	6 59	> ♃ ≻ ♀	63	45	46	...	345+ 2	2
Oct. 22	12 16	3−1	75	56	44	36	98+14	2
Nov. 17	11 9	1	77	66	91	30	150+21	2
23	8 5	> ♀	59	36	52	21	46+ 5	3

Jan. 27. A very brilliant object, satisfactorily observed.
Mar. 23. The radiant point is uncertain.
April 21. The radiant may have been at 294°±0° and height of the meteor 87 to 79 miles.
Aug. 5. A fine, flashing *Perseid*, leaving a streak visible for 20 secs. though the full moon was shining.
Sept. 1. The radiant possibly at 314°+10°.
Nov. 17. A bright *Leonid*, with abnormally slow motion.

Fall of a Meteorite at Sea.—Capt. Anderson of the vessel *African Prince*, writing to his principals, says, "We sometimes hear of vessels disappearing during a passage of fine weather and in the open sea, free from navigation dangers. My experience on the voyage from New York has suggested to my mind that ships may have occasionally been lost by meteors falling on them.

"On the evening of Oct. 17, 1906, I was on the bridge with the second officer, when suddenly the dark night became as light as day and an immense meteor shot perpendicularly towards the earth. Its train of light was a broad electric coloured band, gradually turning to orange, and then to the colour of molten metal. The meteor entered the water with a hissing noise close to the ship, and the consequence, had it struck our ship, would have been annihilation." W. F. D.

Solar Activity in 1906.

Sun-spots.—The general character of the sun-spot activity of 1906 has been that of the last phase of maximum. There has been a distinct falling off in the mean daily spotted area as compared with 1905, though spot-groups have still been numerous, especially in the northern hemisphere. But the giant groups so

characteristic of 1905 have been much less frequent, and the tendency has been rather to develop long processions of groups of moderate size following each other at short intervals along a parallel of latitude, than to concentrate into great disturbances. Still, groups of the first order of magnitude were seen on four occasions during the year, viz.—January 21–30, March 16–27, July 27–August 5, and December 12–25—two great disturbances being on the disc at the same time during the last of these periods. There was a very striking secondary minimum in October, the sun being free from spots on no fewer than nine days in that month; but a distinct revival set in in November, and the year closed with a period of great activity. The mean daily total spotted area will probably work out as about three-fourths that for 1905, so that the crest of the wave seems to have been passed; it may provisionally be taken as being placed in October 1905. Faculæ, on the other hand, have been about as numerous as in 1905, and have, in general, showed no great fluctuation from month to month.

The mean latitude of the spotted area continued to be about 13° from the equator; that is to say, the zone usually occupied at maximum has already been passed. E. W. M.

The Prominences.—The daily frequency of prominences deduced from spectroheliograms taken on 45 days during the year 1906 was practically the same as that deduced for the preceding year from photographs secured at the Solar Physics Observatory, South Kensington. The pictures were taken through the "K" line (calcium) of the solar spectrum, and the lower limit for height of prominences accepted was 20″. The preponderance of activity in both years was manifested in the northern hemisphere of the Sun, the figures obtained being as follows:—

	1905.	1906.
North hemisphere	3·4	3·9
South ,, ...	3·0	2·6
Total daily frequency ...	6·4	6·5

The decrease in the daily frequency for the southern hemisphere is noticeable, though the increase in the northern more than counterbalances it. The most active prominence zones were in the spot latitudes, and in belts about 30° higher. Many equatorial prominences were registered, while 6·5 per cent. of the total number for the whole limb were within 10 degrees of the Sun's poles.

From June 6th to the 11th a strong, persistent, and extensive group of prominences was shown clustered round the north pole of the Sun. On a negative taken on the 27th August a remarkable broken flame of bright calcium, extending for 139,000 miles radially from the photosphere, was seen projecting from the western limb in the spot latitude of the northern hemisphere. It rapidly disappeared, for on another photograph specially taken forty minutes afterwards no trace of it could be detected.

The prominence activity for the first six months of 1906 was given by the late Professor Mascari from visual observations at Catania, the lower limit for their height being taken as 30″. A moderate increase of activity is indicated for this half-year over the mean of the preceding year. The mean daily frequencies are as follows:—

1905 . . . 3·02
1906 (first six months) 3·92.

This increase is somewhat greater than that indicated by the South Kensington photographs, though the actual daily frequency, as given by the negatives, is much higher.

Mr Eversheld, in his last report to the Society, gave $+75°$ and $-75°$ for the prominence limits in 1905. A remarkable feature of the distribution in 1906 was the prominence activity in the neighbourhood of the solar poles. In the observations of Mascari, prominences within 10° of the solar poles are recorded in the years just preceding the spot maximum of 1884, but since that date they are sharply restricted to the year 1894. Their almost complete absence in the remaining years is striking. W. J. S. L.

Double Stars.

The same classification is adopted as in previous reports. The abbreviations are:—

M. N.: Monthly Notices R.A.S.
A. J.: Astronomical Journal.
L. O. B.: Lick Observatory Bulletin.
A. N.: Astronomische Nachrichten.
B. A. A.: Journal of British Astronomical Association.
A. S. P.: Publications of Astronomical Soc. of Pacific.

Observations—

Rev. T. E. Espin. M. N. lxvi. 7. A catalogue of 42 new double stars in the zone $+30°$ to $+40°$.

Royal Observatory, Greenwich. M. N. lxvi. 8. Measures of double stars made in the year 1905 with the 28-inch refractor.

John Tebbutt. M. N. lxvi. 9. Measures of 6 southern binaries.

Rev. T. E. Espin. M. N. lxvii. 3. A catalogue of 80 new double stars in the zone $+29°$ to $+34°$.

Rev. T. E. Espin. M. N. lxvii. 3. Measures of 80 Herschel and 27 miscellaneous stars made in 1906.

J. Nangle. B. A. A. xvii. 1. Measures of *α Centauri*.

H. E. Lau. A. N. 4078. A set of measures of 16 miscellaneous pairs and 68 Struve pairs made for *Memoirs R.A.S.*, vol. lvi.

G. van Biesbroeck. A. N. 4107–8. A fine series of measures made with the 12-inch refractor at Heidelberg. 21 miscellaneous pairs and 185 Struve pairs made at the request of Mr Lewis.

H. E. Lau. *A. N.* 4111. A continuation of the previous measures, containing 52 Struve and 28 miscellaneous pairs.

E. E. Barnard. *A. N.* 4128. A fine set of measures of 61 *Cygni* on 144 nights (last 1906 July 7, 127°·8, 22″·72). These do not confirm Dr Wilsing's hypothesis of a periodic oscillation in distance.

E. E. Barnard. *A. N.* 4128. Measures of Σ 2398, Σ 1110, and Σ 2220.

W. Doberck. *A. N.* 4130. A fine set of measures of 200 pairs made at Hong-Kong in 1904–5.

H. E. Lau. *A. N.* 4134. Measures of ξ *Ursæ Majoris* on 61 nights in 1905–6.

R. G. Aitken. *L. O. B.* 93. Catalogue of 350 new doubles, of which 267 are separated less than 2″. This makes 1250 of this class of double star discovered by Professor Aitken at Lick.

H. Morgan. *A. J.* 584–5. Measures of 19 double stars with the 12-inch Morrison refractor.

R. G. Aitken. *A. S. P.* 108. Measures of Hu 1176, A 570, A 691, and discovery of Σ 2348 as a close double.

Calculation—

W. Bowyer and *H. Furner.* *M. N.* lxvi. 7. On the orbit and relative masses of 85 *Pegasi* (β 733). Faint star four times the mass of the bright star.

A. C. D. Crommelin. *M. N.* lxvii. 2. Proper motion of *Castor*.

T. Lewis. *Memoirs R.A.S.* vol. lvi. Measures of the stars of Struve's *Mensuræ Micrometricæ* collected and discussed.

G. D. Hirst. *B. A. A.* xvii. 1. Note on α *Centauri*.

F. W. Dyson. *B. A. A.* xvii. 1. Review of *Memoirs R.A.S.*, lvi. Struve double stars.

A. C. D. Crommelin. President's Address. *B. A. A.* xvii. 1. Exposition of *Memoirs R.A.S.*, lvi.

W. Doberck. *A. N.* 4110. Elements of orbit of 85 *Pegasi*.

W. Doberck. *A. N.* 4115. Elements of orbit of 70 *Ophiuchi*.

H. D. Curtis. *L. O. B.* 98. The system of *Castor*. Radial velocity curves showing both a^1 and a^2 to be spectroscopic binaries—a^1 the fainter, 3·7 mag., has period 2·928 days; a^2, mag. 2·7, has period 9·219 days.

R. G. Aitken. *L. O. B.* 101. Orbit of β 612 (period 34·4 years).

A. Hall. *A. J.* 588. Note on μ^1 *Herculis*.

R. G. Aitken. *A. S. P.* 104. Note on 13 *Ceti* (period 7·1 years).

R. G. Aitken. *A. S. P.* 106. Note on 95 *Ceti*, Σ 554, β 971, and β 163.

R. G. Aitken. *A. S. P.* 110. Review of *Memoirs R.A.S.* lvi. Struve double stars.

E. W. Maunder. *Knowledge*, 1906 September. A great catalogue of double stars (review).

Miss A. M. Clerke. *Observatory* No. 369. Note on spectral changes of ζ Boötis.

T. Lewis. *Observatory* No. 373. Colours and magnitudes of double stars.

W. J. Hussey. *Observatory* No. 376. A memoir on double stars (review).

R. T. A. Innes. *Observatory* No. 379. Note on κ *Toucani*.

S. W. Burnham. *Popular Astronomy*, xiv. 9, 1906, November. Review of *R.A.S. Memoir*, lvi. T. L.

Variable Stars.

Progress in the discovery of new variable stars has continued during 1906, the highest provisional number allotted so far to a new discovery being 1906, 122 (*A. N.* 4131), and this number may be taken to represent, at the least, the number of new stars found in the year.

Harvard College Observatory is in the front rank in this line of research. The following announcements, among others, have been made:—

H.C.O. Circular.	Number of New Variables.	Remarks.
107	25	All very faint. Chiefly in *Orion* and *Cygnus*.
111	13	Discovered from their peculiar spectra. Principally in N. hemisphere.
115	22	In *Carina*. One is *Algol* type.
117	1	C.D.M. – 30° 16169. Varies 1 mag. in two days. *Algol* type.
120	31	All in S. hemisphere, and principally in *Crux*, *Centaurus*, etc. One of them is *Algol* type. Nearly all faint.
121	1	*Nova Velorum*. Variation $< 11{\cdot}5$ to $9{\cdot}8$.
122	36	Principally in *Carina* and *Centaurus*. Six probably *Algol* type.

Mr A. Stanley Williams continues his studies of certain known variables (*A. J.*).

In *H. C. O. Circular* 116, Professor E. C. Pickering, with characteristic energy, proposes that as the number of known variables now amounts to over 3000, the time is ripe for the compilation of a D. M. of variable stars, with the view of ascertaining the proportion of the different classes, and their general distribution in the heavens. He estimates the number of the stars of the 16th magitude and brighter at fifty millions. His project involves the examination of all these stars by the method of superposing one photographic plate on another taken at a different time from the first. It is, of course, a huge task, but with the rapid and sweeping method indicated it is considered as not beyond the powers of the present generation of observers. He considers that

although co-operation of astronomers is necessary, there is at present no need for a formal organisation and allotment of work. The field is so large as to admit of different observers working independently; it is only required that their work should not overlap or clash.

Dr A. W. Roberts has published an important paper on "A Method of determining the absolute Dimensions of an *Algol* Variable Star" in *Monthly Notices*, vol. lxvi. No. 3.

The Carnegie Institution of Washington has recently issued *Researches in Stellar Photometry*, made chiefly at the Yerkes Observatory, by J. A. Parkhurst, during the years 1894–1906. This work refers to 12 variable stars, 10 of which may be called recently discovered stars. The object proposed was (1) the accurate determination of the complete light curves, and (2) the behaviour of the variables during their faint stages. The number of visual observations is 1405. Special attention has been given to the magnitudes of the comparison stars which have been ascertained from photometric measures. With each star are given plates showing the magnitude curve, the light curve, and the mean light curve; also a very clear chart of the vicinity of the variable, showing all the stars in the field, the comparison stars being lettered. The work was done with three different telescopes, of 6, 12, and 40 inches aperture. The break of continuity in the visual observations resulting from the use of these three instruments "was kept within limits by the use of the photometric magnitudes of the comparison stars." The work must occupy an important place in the research in the long-period variables. A point which strikes one is that the figures representing the light curves might have been more opened out, *i.e.* the ratio length representing magnitude to that of time being made greater, by which the minor fluctuations superposed on the main curve would have been rendered more apparent to the eye.

Vol. xv. of the *Memoirs* of the British Astronomical Association has just been published, being the sixth report of the Variable Star Section, by Col. E. E. Markwick, C.B. It contains in detail 5717 observations of 26 well-known long-period and two irregular variable stars, made by twenty-one members in the years 1900–1904 inclusive. There are appended plates showing at a glance the light curves of these stars, as deduced from the observations drawn on the scale—length representing one magnitude (ordinate) = that representing 20 days (abscissa). The theoretical curves are also given, so that the difference "O–C" is readily visible to the eye for any specified date. E. E. M.

Stellar Spectroscopy in 1906.

Nebulæ.—The apparent persistency of unaltered form in some of the large gaseous nebulæ has frequently attracted attention. A great part of the luminosity of such nebulæ is recognised as being due to the glowing of hydrogen, helium, and another unidentified

vapour. In a characteristic note contributed to the *Observatory* (October 1906, p. 380), one of our honorary members, Miss Agnes M. Clerke, whose recent death is deplored in a circle far wider than that of our own Society, has suggested an attempt to bring the work of the physicists, J. J. Thomson, Ramsay, and Rutherford, into line with the observations of astronomers.

In the nebula near π and δ Scorpii recently photographed by Professor Barnard on Mount Wilson (*Astroph. Jour.*, xxiii. 144), most of the larger stars involved have spectra of the *Orion* type, with the characteristic absorption lines of helium.

New Stars.—A star, exhibiting the photometric peculiarities of a Nova, has been discovered by Miss Leavitt at Harvard College Observatory. Professor E. C. Pickering, in announcing it (*Ast. Nach.*, 173, 295, *H. C. O. Circular*, No. 121) as Nova *Velorum*, says that it is not impossible that it may again become sufficiently bright for its spectrum to be obtained, and adds that "even without such proof there can be little doubt that the object observed is actually a Nova."

The spectrum of Nova *Aquilæ* No. 2 has been observed by Mr J. H. Moore at the Lick Observatory (*Astroph. Jour.*, xxiii. 261).

Classification of Stellar Spectra.—The published notes on this branch of the subject during the year relate almost entirely to the relation between the spectra of sun-spots and stars; a study of great importance, and likely to throw much light on methods of classification of stellar spectra. The following papers may be noted:—

"Spectra of sun-spots and *Arcturus*," W. S. Adams (*Astroph. Jour.*, xxiv. 69). Attention should also be called to Sir N. Lockyer's paper (*Proc. R.S.*, lxxiv. 53). "Spectra of sun-spots and Third type Stars," G. E. Hale and W. S. Adams (*Astroph. Jour.*, xxiii. 400). "Spectra of sun-spots and Fourth type Stars," W. M. Mitchell (*ibid.* xxiii. 211). "On the relation between Stellar Spectral types and the intensities of certain lines in the spectra," S. Albrecht (*Astroph. Jour.*, xxiv. 333). "Enhanced lines of Iron in the region F–C," A. Fowler (*M. N.*, R.A.S., lxvii. 154). "Preliminary paper on the cause of the characteristic phenomena of sun-spot spectra," G. E. Hale, W. S. Adams, H. G. Gale (*Astroph. Jour.*).

Here also we may note a paper by Miss Agnes Clerke—probably the last written by her before her death—on sun-spot spectra (*Observatory*, January 1907, p. 55).

Studies of Special Stars.—At a time when the maximum in the brightness of o *Ceti* is shown by Father Sidgreaves (*Observatory*, January 1907, p. 49) to be again accompanied by extreme brilliance of the hydrogen lines, and by peculiar behaviour of the H_β line in particular, it is of interest to record Professor Frost's observations of *Pleione* (*Astroph. Jour.*, xxiii. 268). The hydrogen lines in *Pleione* have been frequently seen bright and narrow, superposed on broader dark lines. Frost now observes that the

bright lines are no longer visible. Professor Pickering corroborates this observation in 1906, at any rate with respect to H_β, which was often recorded as bright in 1896.

Sir N. Lockyer has a note in the *Proc. R.S.*, **77**, 550, on peculiarities in the spectra of α *Andromedæ*, θ *Auriyæ*, α *Canum Ven.*, and ϵ *Ursæ Majoris.*

Herr Ludendorff (*Ast. Nach.*, **173**, 1) publishes remarks upon the spectra of *R. Coronæ Borealis*, 12 *Canum Ven.*, and 72 *Ophiuchi.* The first-named star has a spectrum similar to that of α *Persei*, except that the H_γ line seems to be absent. Professor Frost corroborates the absence of the hydrogen lines in 1903.

A list of 24 stars with peculiar spectra is given by Professor Pickering (*H. C. O. Circular*, No. 110, and *Ast. Nach.*, **171**, 139, *Astroph. Jour.*, xxiii. 257). Reference is here made to *R Cygni*, which is also the subject of a note by Miss Clerke in the *Observatory*, April 1906.

Radial Velocity of Stars.—In a note on sun-spot lines in spectra of Red Stars, G. E. Hale and W. S. Adams give parenthetically the velocity of α *Orionis* + 26·7 km/sec. (*Astroph. Jour.*, xxiii. 402).

Variable Radial Velocity.—Notes on variability of velocity are given for the following stars :—

(The numbers prefixed in the first column refer to Campbell and Curtis's First Catalogue, *L.O.B.*, No. 79. Here also it may be remarked that Professor Campbell gives (*L.O.B.* No. 107) a list of changes to be made in the first catalogue.)

29	ϵ Aurigæ	Ludendorff	*Ast. Nach.* **171**, 49
80	α Draconis	,,	,, **171**, 127
12	β Arietis	,,	,, **171**, 149
	γ Cassiopeiæ	Hartmann	,, 173, 101
	RZ Cassiopeiæ	,,	,, 173, 101
65	o Leonis	Zurhellen (Bonn)	,, 173, 353
	* Orionis B.D. -1° 1004	Frost	*Astroph. Jour.* xxiii. 264
	29 Canis Majoris	,,	,, ,, 265
	30 (τ) Canis Majoris	,,	,, ,, 265 (footnote)
	μ Orionis	,,	,, ,, 266
	T Monocerotis	,,	,, ,, 266
80	α Draconis	,,	,, ,, 267
129	β Cephei	,,	,, xxiv. 259
	1 Geminorum	Campbell and Moore	*Pub. A.S.P.* **18**, 308, and *L.O.B.* No. 107.
	* Ophiuchi (Draper C. 7579)	,, ,,	,, ,,
	δ Sagittæ	,, ,,	,, ,,
	o_2 Cygni	,, ,,	,, ,,
	ϵ Cygni	,, ,,	,, ,,
	ζ Cygni	,, ,,	,, ,,
	ι Capricorni	,, ,,	,, ,,
	SU Cygni	Maddrill	*Pub. A.S.P.* **18**, 252, and *L.O.B.* No. 107.
	α Scorpii (Antares)	Wright	*L.O.B.* 107

7 α Ursæ Minoris (Polaris)	Campbell	*L.O.B.* 107
β Reticuli	Wright	,,
m Velorum	,,	,,
ν Centauri	,,	,,
ν_2 Centauri	,,	,,
δ Capricorni	Slipher	*Astroph. Jour.* xxiv. 361
τ Ursæ Majoris	Moore	,, xxiii. 263
λ Hydræ	,,	,, ,,
μ Ursæ Majoris	,,	
Y Ophiuchi	Albrecht	*Pub. A.S.P.* 18, 66
U Aquilæ	,,	,, 18, 142

Orbits of Spectroscopic Binaries.—The binary character of the fainter companion of *Castor* was discovered by Belopolsky in 1896; his later work led him to the view that there was a rotation of the line of apsides. The observations made at the Lick Observatory have been fully discussed by Mr H. D. Curtis (*Astroph. Jour.*, xxiii. 351), and he is led to abandon the assumption of any rotation in the line of apsides and to adopt an orbit nearly circular, $e = 0{\cdot}01$. In October 1904 Mr Curtis announced the variation in the radial velocity of the brighter component; and he deduces for it an orbit which exhibits signs of considerable eccentricity, $e = 0{\cdot}50$. Doberck, in his last discussion of the visual system, arrives at the conclusion that the period 347 years is the most probable. The relative motion of the two component systems derived by Mr Curtis is 7·14 km/sec.; and the periods are 9·2188 days and 2·9283 days for the bright and the faint components respectively. Mr Curtis has searched for variability in the light of the brighter component, but has not detected any.

From a discussion of radial velocities deduced at the Lick Observatory from 56 photographs of the spectrum of λ *Andromedæ*, Mr K. Burns has calculated an orbit with a period of 2·05 days (*Astroph. Jour.*, xxiv. 345). Further observations are required to decide whether there is a change in the elements.

Radial Velocities from Objective Prism.—The importance of devising a wholesale method of gathering information about radial velocities is widely recognised. Three notes on practical suggestions have been made in the last year.

Professor E. C. Pickering (*Astroph. Jour.*, xxiii. 255) recalls the method suggested by him in *Harvard Circular* No. 13—two exposures with the prism reversed. Mr G. C. Comstock (*Astroph. Jour.*, xxiii. 148) suggests the use of a single object-glass with a direct-vision objective prism in front of each half of the object-glass, the prisms being fixed with their refracting edges in opposite directions.

Mr De Lisle Stewart (*Astroph. Jour.*, xxiii. 396) describes a form of instrument with two object-glasses, each having an objective prism in front of it; by appropriate inclination of the axes of the lenses, and by separation of their centres, the two spectra may be set side by side on one photographic plate in opposed directions.

Reduction of Observations.—Dr H. K. Palmer (*Astroph. Jour.*, xxiv. 51) contributes a note on a short method of computing an approximate value of the reduction to Sun in radial velocity determinations. Dr Hartmann (*Ast. Nach.*, **173**, 97) remarks upon the method, suggests the utilisation of the distance of the star from the apex of the Earth's motion, measured on a great circle, and describes a practical method of obtaining the required result by readings from a globe. H. F. N.

The Astrographic Chart and Catalogue.

There is little to record in connection with the Astrographic Chart beyond what may be gathered from the Proceedings of Observatories in another part of this report. The publication of the measures of stars of the northern zones is progressing. The printing of the rectangular co-ordinates of the Greenwich zone, Dec. $+64^\circ$ to the Pole, is practically complete. Oxford University Observatory has published its first volume of measures Dec. $+29^\circ$ to $+31^\circ$, a second volume is on the eve of publication, a third is being printed, and five more volumes will complete the Oxford section. Nothing has issued from the French observatories during the year 1906, although the work of publication already begun at Paris, Bordeaux, Toulouse, and Algiers is no doubt proceeding. M. Loewy mentioned in his annual report that the work at Paris had been delayed by the death of M. Paul Henry, and possibly the death of M. Rayet at Bordeaux has caused a similar hindrance. M. Henry has been succeeded in the superintendence of this branch at Paris by M. Puiseux.

Three volumes were published from Potsdam in the years 1899–1903, and it appears that four more volumes of measures were prepared for printing some time ago, but the publication was delayed by the computation of the plate-constants. As to the zone 47° to 64°, which is divided between the Vatican Observatory at Rome and the Catania Observatory, nothing has appeared since the first volume was issued from Rome in 1903. Father Hagen, the newly appointed Director of the Vatican Observatory, paid a visit to Greenwich last summer for the special purpose of making himself acquainted with the details of the astrographic work.

Of the zones which cover the sky south of the equator,* that between Dec. 32° and 40° undertaken at a later date than most of the others by the Observatory at Perth, West Australia, seems to be making small progress. The staff of this observatory is evidently inadequate to effect the measurement of the plates unless some other work of the observatory is discontinued. The

* Since the above has been in type a letter has been received from M. Valle, Director of the Tacubaya Observatory, Mexico, saying that 1200 of the 1260 catalogue plates required to cover the zone -10° to -16° have been taken, and that the computation of the plates, declination -15° and -16°, between R.A. 0^h and 4^h, will be completed, and the results printed in a few weeks. Some progress has also been made in taking the chart plates.

exact state of the work between this zone and the south pole will be learned from the reports of the British Colonial Observatories. A suggestion has been made that another conference should be held at a near date; should this take effect, information gathered as to the position of affairs at all the observatories might indicate any rearrangements necessary to bring the whole work to a conclusion, and discussion might lead to resolutions as to the procedure which should follow the publication of the measures.

Enlargements of the Chart Plates have been distributed during the year by the Directors of the Paris, Algiers, Toulouse, Bordeaux, San Fernando, and Greenwich Observatories. The total number issued from these observatories is now

Paris 271	Bordeaux 64
Algiers 276	San Fernando 95
Toulouse 122	Greenwich 538

H. P. H.

Star Catalogues.

A number of important star catalogues have appeared during the year. In this note it is only possible to enumerate them and indicate their scope.

Catalogue of Zodiacal Stars for 1900 *and* 1920.—This is published as vol. viii. part iii. of the Astronomical papers of the American *Ephemeris*. The catalogue contains 1607 stars, and is prepared principally for use in occultations of stars by the Moon. In determining positions of the stars and their proper motions, the more important catalogues from 1755 to 1900 have been used, after being reduced to the system of Newcomb's Catalogue of Fundamental Stars. This catalogue contains 1000 stars which may be regarded as fundamental. The positions of the remainder will be improved very considerably by recent observations of zodiacal stars.

Cape General Catalogue for 1900.—This catalogue contains 3365 stars which are north of the zenith at the Cape and 995 south of the zenith. The catalogue contains the results of observation at the Cape of 2798 zodiacal stars contained in a list circulated by Sir David Gill, and adopted at the Paris Conference of 1896 as forming a suitable basis for a catalogue of zodiacal stars in connection with heliometer observations of planets, occultations, etc. The remainder of the stars are, generally speaking, stars brighter than $8^{m}\cdot5$, which are not found in any catalogue of precision. The stars are generally observed five times, the epoch being about 1902 or 1903. The right ascensions are corrected for personal equation depending on magnitude. The declinations are reduced to the system of Newcomb's Fundamental Catalogue.

Radcliffe Catalogue for 1900.—The Radcliffe Catalogue of 1772 stars continues the programme of the Radcliffe Catalogue for 1890. The 1890 catalogue contained all stars down to $7^{m}\cdot0$

from the equator to $-25°$ dec.; the present catalogue contains all stars to $7^m{\cdot}0$ between the equator and $+5°$ dec. A large number of the zodiacal stars contained in the Zodiacal Catalogue of the American *Ephemeris* and in the Cape Catalogue are also observed here. Attention may be called to the determination of pivot errors, and the new determination of the division errors given in the introduction.

Henderson's Catalogue for 1840.—*The Annals of the Edinburgh Observatory*, vol. ii., consists of a reduction by Dr Halm of the observations made at the observatory on Calton Hill by Henderson and his assistant Wallace. The catalogue contains 3595 stars from the pole to dec. $-20°$, nearly all brighter than $7^m{\cdot}0$, observed between 1835 and 1845 with a transit instrument by Repsold and a mural circle by Troughton & Simms. The principal differences between the new and old reductions are, in the right ascensions, the elimination of the effect of the heat of the illuminating lamp on the level and azimuth, and in the declinations, the correction for division errors. The positions of the clock stars, etc. are taken from Auwers' Fundamental Catalogue.

Ambronn's Catalogue of all Stars to $6^m{\cdot}5$ *for* 1900·0.—This compilation from the Catalogues of the *Astronomische Gesellschaft*, the Argentine General Catalogue, and other sources, contains 7796 stars, whose positions are given to $0^s{\cdot}1$ in R.A. and $1''$ in dec., and may be very useful where approximate places of bright stars are required.

The catalogues referred to above are in the main concerned with fairly bright stars. The catalogues which follow contain fainter stars.

Cape Catalogue of Astrographic Standard Stars for 1900·0.—The purpose of this catalogue is to provide accurate positions of stars to serve as reference stars for the Cape Section of the Astrographic Catalogue. It contains 8560 stars between the declinations $-40°$ and $-52°$. All are observed three times, many of them five times, the observations being all made in the four years 1896 · 1899. The accidental probable error of a single observation is given as $\pm^s{\cdot}024$ sec δ in R.A. and $\pm 0''{\cdot}28$ in declination, so that the accidental error of a result depending on three or five observations is very small. The point of special interest in the reductions is the application of zone corrections to each series of observations derived by comparison of 10 or 12 selected stars each night with the means of these stars from all observations. Magnitude equation has been applied separately for each observer.

Extensive comparisons are made with earlier catalogues, from which proper motions of a large number of stars have been deduced. These proper motions depend to a large extent on the Cordoba Catalogues, and it is stated that they cannot be used for purposes of cosmical research without further investigation of the systematic errors of that catalogue. The proper motions are, however, sufficiently accurate for the immediate purpose of the

catalogue, which is that of forming a secure foundation for the Cape Section of the Astrographic Catalogue.

Astronomische Gesellschaft Catalogue (*2nd Section*), *Strassburg Zone*.—This catalogue, which forms the first division of the A. G. Southern Catalogue (-2° to -23°), extends from dec. -2° to dec. -6°. It contains 8204 stars, being all the stars to $9^{m}\cdot0$ and fainter ones according to the A. G. programme. The positions are given for 1900·0 (not 1875·0 as in the N. Section of the A. G. C.), and are reduced to the system of Auwers' Southern Fundamental Catalogue. The average number of observations on which a catalogue place depends is nearly three, and the probable errors are about $\pm^{s}\cdot021$ and $\pm0''\cdot27$, being uniform in declination for all magnitudes, but in right ascensions ranging from $\pm^{s}\cdot017$ for bright stars to $\pm^{s}\cdot024$ for those fainter than $9^{m}\cdot0$.

Astronomische Gesellschaft Catalogue (*2nd Section*), *Wien, Ottakring Zone*.—This catalogue, forming the second division of the A. G. Southern Catalogue, was published in 1904, but has not yet been referred to in the Council reports. It extends from -6° to -10° dec. and contains 8468 stars. The probable accidental error seems to be about the same as in the Strassburg Zone.

In this connection it may be noticed that the reductions of the observations for the remaining zones, Cambridge U.S. (-10° to -14°), Washington (-14° to -18°), and Algiers (-18° to -23°), are being rapidly pushed forward. F. W. D.

Universal Time.

Since the last mention of the subject of Universal Time in this Report (1905 February), the time system of India has been altered as there indicated. From 1905 July 1 the standard time of India has been $5\frac{1}{2}$ hours fast on Greenwich, that of Burmah $6\frac{1}{2}$ hours fast, but the time-ball of the Colaba Observatory, Bombay, is dropped at exactly 3^{h} a.m. Greenwich time.

It has been enacted by the Council at Port Louis that from 1907 January 1 the standard time throughout Mauritius and its dependencies shall be the time of the meridian sixty degrees east of Greenwich, except for the Chagos archipelago, where the standard time 5 hours east has been adopted from the same date. The time 4 hours fast on Greenwich is now also standard in the colony of the Seychelles. H. P. H.

Geodesy.

The new gravimetric Survey of India, begun in 1904, is still proceeding, and some results of a preliminary nature have appeared during the last two years in the publications of the Royal Society. The history of the subject of gravity in India begins in the year 1865, between which year and 1873 observations were made by

officers of the Survey at 31 stations in India with the Royal Society's invariable seconds pendulums. The results of these operations showed considerable discordances from the values of gravity as computed by Clairaut's law, and their physical meaning was for some time a matter of discussion. At 15 inland stations under 2000 feet above sea-level the number of swings of a "seconds" pendulum was 2·27 less per day than that computed from theory. At 4 stations between 2000 and 7000 feet high the defect was as much as 5·09, and at one station, in the Himalayan table-land, 15,400 feet above sea-level, the invariable pendulums made 21½ swings per day less than was expected. The deficiency of gravity which was then found to exist in Himalayan regions was attributed by different authorities to different causes, but lately there seems to have been some doubt as to the actuality of the fact itself, for at the International Conference of the Geodetic Association at Copenhagen in 1903, a resolution was passed for submission to the Government of India to the effect that it was desirable to make an accurate determination of the distribution of gravity in the mountainous country and in the plains of India. This work was begun in India in 1904, with a set of half-second pendulums of the Von Sterneck pattern, which were previously swung at Kew in 1903, with the primary object of standardising the instruments. As, however, on the suggestion of the Astronomer Royal, a series of swings were also made at Greenwich, the results gave a difference of the value of gravity at the two observatories. This observed difference * of 0·014 dynes excess at Kew is rather larger than the theoretically computed difference, which is +0·005 if the corrections for the known geological strata around the two places be included, but the accordance between computed and observed is nearer than in previous determinations made with the older form of instrument, and there is close agreement between two sets of operations that have been made with half-second pendulums.

The results found in India by Major Lenox-Conyngham, so far as yet published,† are remarkable. At Dehra Dûn, Madras, Bombay, Mussooree, the force of gravity, as recently determined, is larger than the earlier value by a considerable quantity, so that Colonel Burrard feels justified in saying that "the idea that gravity is exceptionally weak throughout India as compared to Europe can no longer be upheld, and the so-called marked negative variation has been found to rest on erroneous data."

The same memoir in the *Philosophical Transactions* contains an account of observations made to determine the local deflection of gravity over India. An earlier publication ‡ on this subject showed that local deflections of gravity could be classified in groups, and to test this, observations for latitude have been made

* *Proc. Roy. Soc.*, 1906 November 5.

† "On the Intensity and Direction of the Force of Gravity in India," by Lieut.-Col. Burrard, R.E., F.R.S., *Phil. Trans.* 1905.

‡ Survey of India Department, Professional Paper No. 5, 1901.

under Col. Burrard's direction at various stations along a meridian, or rather along each of several meridians, with a result which proved to be very much as expected. In the mountainous regions of the Himalayas the plumb-line is deflected northward by more than 30″; in the plains the deflection is in the same direction, but much less in amount. Further south, and parallel with the Himalayas, is a tract of country 4000 miles long and 200 broad, where the plumb-line is deflected in the opposite direction, *i.e.* towards the south; and having passed through that zone of southerly deflection into the Indian peninsula or into north-west India, the plumb-line is again found to be deflected northward. Discussing these determinations, the conclusions are arrived at that there is a local deflection of gravity at Kalianpur, the origin of the Survey, and that a spheroid which has the ellipticity of Bessel, 1/299·15, but the semi-major-axis found by Col. Clarke, 6,378,190 metres, best represents the facts of Indian geodesy.

Details of the geodetic work done in South Africa will be found in the report of the Cape of Good Hope Observatory. It appears that the measurement of the meridian 30° east of Greenwich is complete, or nearly so, as far north as latitude 13° 58′ S. And here it may be mentioned that the Survey department of Egypt, under the directorship of Captain H. G. Lyons, D.Sc., F.R.S., has begun the preliminary work of the geodetic triangulation of Egypt, which it is hoped will ultimately be connected with the triangulation in the southern part of the Continent (an intermediate section being measured by Germany), and so complete the measurement of this 30th meridian from 34° S to 30° N. As Captain Lyons says in his Report for 1905, it seems only fitting that the country where Eratosthenes (B.C. 275–196) did the first geodetic work, should take a share in the modern re-determination of the earth's form.

During the year a volume has been published by the Astronomer Royal containing the details of several determinations of longitude made by the Greenwich staff in the years 1888–1902. The results given in the first part of this, the difference of longitude between Greenwich and Paris, have already appeared in the *Monthly Notices*. The second part comprises the determination of a trans-Atlantic arc, Greenwich-Montreal, and the measurement of the arcs between Greenwich and Waterville and Killorglin in the south-west of Ireland, which are of some interest. This point of the United Kingdom is of geodetic importance, since it forms the western end of the great European arc in the parallel of latitude 52° N, and in the middle of the last century three separate determinations of longitude agreed in showing that the astronomical value of the arc was greater than the geodetic when Clarke's first values ($a = 20{,}926{,}348$ feet, $b = 20{,}855{,}233$ feet) were used for the spheroid assumed to represent the Earth's surface. The suggestion was made at the time that the difference was due to local attraction at the western stations, but the amount was larger than was consistent with any reasonable hypothesis. The new determinations

continue to show the astronomical value greater than the geodetic, the same spheroid as before being assumed in the computation of the latter, but the difference is not so large. The excess in the case of Waterville is $0^s.37$, in the case of Killorglin $+0^s.15$.

In a short paper * on the size of the Earth, Professor Helmert combines the values of recent arcs which connect Greenwich with the Continent and the arc Greenwich–Killorglin, with previous discussions of the great European arc, and arrives at a correction of +660 metres to the a found by Bessel; or, in other words, the derived equatorial radius of the Earth is 6,378,057 metres, or 20,925,572 feet. Professor Helmert gives this result with some reservation, apparently with reference to the fact that the question of local attraction at the Western stations has been treated only by an approximate method.

The triennial Conference of the International Geodetic Associations was held in 1906 at Buda Pest; the subjects of the measurement of the arc in Peru by French Geodesists, the survey of Africa, and Indian geodesy formed part of the proceedings. Sir George Darwin expressed the wish that it might be possible to hold the next meeting of the Association at Cambridge, regretting that it was not in his power to do more than make the suggestion. A formal invitation to England must proceed from the British Government. H. P. H.

* "Die Grösse der Erde," *Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften*, 1906, xxvii. p. 523.

List of Public Institutions and of Persons who have contributed to the Library, etc. since the last Anniversary.

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Calcutta, Asiatic Society of Bengal.
Canada, Department of Marine.
Canada, Geological Survey.
Canada, Royal Society.
Cape of Good Hope, Royal Observatory.
Cape Town, South African Philosophical Society.
Catania, Italian Spectroscopic Society.
Catania, Royal Observatory.
Colorado College Observatory.
Copenhagen, Royal Danish Academy of Sciences.
Cracow, Academy of Sciences.
Delft, Geodetic Commission of the Netherlands.
Dijon, Academy of Sciences.
Egypt, Survey Department.
Geneva Observatory.

Göttingen, Royal Observatory.
Göttingen, Royal Society of Sciences.
Granada Observatory.
Groningen, Astronomical Laboratory.
Halle, Imperial Lepold-Caroline Academy.
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Heidelberg, Astrophysical Observatory.
Heidelberg, Astronomical Institute.
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New York, Columbia College Observatory.
O Gyalla, Central Meteorological and Magnetical Observatory.
Oporto, Polytechnic Academy.
Paris, Academy of Sciences.
Paris, Astronomical Society of France.
Paris, Bureau of Longitude.
Paris, École Polytechnique.
Paris, Mathematical Society of France.
Paris Observatory.

Paris, Philomathic Society.
Pennsylvania University.
Perth Observatory, Western Australia.
Philadelphia, American Philosophical Society.
Philadelphia, Franklin Institute.
Philadelphia, University Observatory.
Pola, Imperial Hydrographic Office.
Potsdam, Astrophysical Observatory.
Potsdam, Central International Geodetic Bureau.
Potsdam, Royal Prussian Geodetic Institute.
Poughkeepsie, Vassar College Observatory.
Prague, Imperial Observatory.
Pulkowa Observatory.
Pulkowa, Physical Observatory.
Queensland Government.
Rio de Janeiro Observatory.
Rome, Royal Academy *dei Lincei.*
Rome, Vatican Observatory.
St Petersburg, Imperial Academy of Sciences.
San Fernando, Observatory of Marine.
San Francisco, Astronomical Society of the Pacific.
Sophia University.
Stockholm Observatory.
Stockholm, Royal Swedish Academy of Sciences.
Stockholm, Swedish Geodetic Commission.
Sydney Observatory.
Tacubaya National Astronomical Observatory.
Tōkyō Astronomical Observatory.
Toronto, Canadian Institute.
Toronto University.
Toulouse, Academy of Sciences.
Toulouse, Meteorological Commission.
Toulouse Observatory.
Turin, Royal Academy of Sciences.
Transvaal Meteorological Department.
Uccle, Royal Observatory of Belgium.
United States Coast and Geodetic Survey.
Upsala, Royal Society of Sciences.
Vienna, Austrian International Geodetic Commission.
Vienna, Imperial Academy of Sciences.
Vienna, Imperial Military Geographic Institute.
Wanganui Astronomical Society.
Warsaw, Observatory of the Imperial University.
Washington, Bureau of Standards.
Washington, Navy Department.
Washington, Philosophical Society.
Washington, Smithsonian Institution.
Washington, United States Naval Observatory.
Yale University Astronomical Observatory.
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Zi-Ka-Wei Astronomical Observatory.
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ADDRESS

Delivered by the President, Mr William H. Maw, on presenting the Gold Medal of the Society to Professor Ernest William Brown, February 8, 1907.

The Gold Medal of the Royal Astronomical Society has this year been awarded to Professor Ernest William Brown for his "Researches in the Lunar Theory," and it is my duty to put before you on the present occasion the grounds for this award. In attempting this, I fear it will be impossible for me to do adequate justice to the importance of our medallist's work. This work is of so special a character, and its development has been marked by the introduction of so many original devices and methods of calculation, that an address such as this is quite unsuited for an examination of the details of the research. All I can hope to do is to put before you the broad features and general extent of Professor Brown's work, and to record the success which he has attained.

Professor Brown is the seventh astronomer to whom the Gold Medal of the Royal Astronomical Society has been awarded for work in connection with the Lunar theory. His predecessors were: Baron Damoiseau (1831) for his "Memoir on the Theory of the Moon," and for his Lunar Tables; M. Jean Plana (1840) for his work entitled "Théorie du Mouvement de la Lune"; Professor P. A. Hansen (1860) for his Lunar Tables; Professor J. C. Adams (1866) for his "Contributions to the Development of the Lunar Theory"; M. Delaunay (1870) for his "Théorie de la Lune"; and Dr G. W. Hill (1887) for his "Researches on the Lunar Theory." This is a long list of illustrious workers, and with them our present medallist is well qualified to rank.

In a paper entitled "Theory of the Motion of the Moon, containing a New Calculation of the Expressions for the Co-ordinates for the Moon in Terms of the Time," published in volume liii. of our *Memoirs*, our medallist has stated so clearly the nature of the problem on which he has been engaged that I may be permitted to quote from his introduction. He says:— "The formation of numerical expressions deduced as a consequence of the Newtonian laws of motion and gravitation which shall represent the position of the Moon at any time may be roughly divided into three stages. As a first step, we consider each of the three bodies—the Sun, the Earth, and the Moon—as a sphere of mass equal to its actual mass, and arranged in concentric layers of

equal density. The Earth (or the centre of mass of the Earth and Moon) is supposed to move round the Sun in a certain ideal elliptic orbit, and all disturbances of this orbit and of the Moon from any other source than the ideal Sun and Earth are neglected. This first stage constitutes nearly the whole of the labour of solving the problem of three bodies as far as the particular configuration of the Sun-Earth-Moon system is concerned. When this is done, we proceed to the second step, which involves the determination of the effects due to the difference between the actual and the ideal motions of the Earth and Sun, to the influence exercised by the other bodies of the solar system, and to the differences between the real and ideal arrangements of the masses of the bodies. The calculations so far may, theoretically at least, be made without any knowledge of the configuration of the system at any given time or times, beyond a general idea of the order of magnitude of certain of the constants involved. The third and final stage consists in a determination by observation of the various constants which have entered into the theory and the substitution of their values, so as to obtain numerical expressions for the co-ordinates in terms of the time."

As we shall see later, it is the completion of the first of these stages which has primarily been the object of Professor Brown's past labours; and as a result he has, after arduous work extending over the past fifteen years, completed the solution of the problem of three bodies for the case of the Sun-Earth-Moon with an accuracy very far in excess of that attained by any of his predecessors in this line of research.

Our knowledge of the motion of the Moon has accumulated during long ages; but it is, of course, only since the time of Newton, or, say, during the past two and a half centuries, that the Lunar theory has had any existence. Our earlier information as to irregularities in the Moon's movements was knowledge derived from observations, and it did not include any explanations of the causes to which these irregularities are due. Before the discovery of gravitation, all that could be done with the motion of the Moon was necessarily empirical. But even Newton, the discoverer of this principle, contented himself with the variation, the motions of the perigee and node, and the largest inequality of the latitude. Analytical expressions giving the position of the Moon in space were not seriously attempted until the middle of the eighteenth century, when three men simultaneously concerned themselves with the problem. They were Clairaut, D'Alembert, and Euler. The last-named, in 1753 and 1772, produced three Lunar theories nearly independent of each other, and of the third of these I shall have more to say later.

Of the six inequalities which affect the Moon's position by an amount capable of being discovered by naked-eye observations, viz. the effect of solar attraction in enlarging the Moon's orbit, the revolution of the line of apsides, the regression of the nodes, the evection, the variation, and the annual equation, only one—that to

which the name of "evection" was given by Boulliaud in the seventeenth century—was known to the ancients. It appears to have been first noticed by Hipparchus, about 150 B.C., when he was engaged in endeavouring to determine the Moon's distance, but it was first taken systematically into account by Ptolemy, to whom, indeed, its discovery has been attributed.

The variation, which has a fortnightly period and a zero value at syzygies and quadratures, does not affect the time of an eclipse, and thus escaped the notice of the Greek astronomers. It appears, however, to have been detected by an Arabian astronomer, Aboul Weta, in the tenth century, but was lost sight of until rediscovered by Tycho Brahé about the end of the sixteenth century. To Tycho Brahé is also due the detection of the annual equation, although he gave it an erroneous value. A more correct value was determined by Horrocks, but its true character appears to have been first appreciated by Flamsteed.

Of smaller perturbations the number is almost endless—seventy such perturbations are, I understand, taken into account in the calculations of the Moon's longitude made for the American Ephemeris, and about half that number in the computations for latitude—but of these the most important, and in many ways the most interesting, is the secular acceleration of the Moon's mean motion; and on this I desire to say a few words. As early as 1693, Halley, after a consideration of the records of a number of ancient eclipses, arrived at the conclusion that these records could only be satisfied by assuming a progressive shortening of the Lunar month. A long period elapsed before this suspicion was confirmed, but in 1749 Dunthorne contributed to the Royal Society a paper discussing all available observations bearing on the subject, and the matter was further investigated by Mayer, Bouvard, and Burg. The explanation of the acceleration, however, long evaded the efforts of the mathematicians, but later the problem was taken up by Laplace, who at length, on November 19, 1787, announced to the Académie des Sciences his discovery that—"The secular equation of the Moon is due to the action of the Sun on the Satellite, combined with the secular variation of the eccentricity of the terrestrial orbit."

Laplace's first value for this acceleration was $11''{\cdot}135$ per century: a value subsequently reduced to $10''{\cdot}18$. The cause of this inequality acts on the Moon as gravity on a falling body, and its effect, therefore, is as the square of the time; but in carrying the calculations back to the time of the Chaldean observations, it was found necessary to add a small term depending on the time cubed. Thus if t = the number of centuries from the assumed epoch, the acceleration, according to Laplace, was equal to $10''{\cdot}1819\ t^2 + 0''{\cdot}01854\ t^3$.

These deductions of Laplace were verified in 1820 by two of our medallists, Damoiseau and Plana, and also by Carlini, their approximations being carried to a higher order than those of Laplace. The value deduced by Damoiseau was $10''{\cdot}72$, and by

Plana 10″·58. These values were all too large; but the error was at once fortunate and unfortunate. It was fortunate in so far that the values arrived at fairly satisfied the discrepancies between the records of ancient eclipses and the results of modern observations, and led to the acceptance of the explanation and the upholding of the gravitational theory; but unfortunate inasmuch as this close agreement had the effect of stopping for the time further research. Moreover, when some twenty years later Hansen took up the matter, he also arrived at a large value which he announced in 1842 as 11″·93, reduced in 1847 to 11″·47.

Things remained thus until another of our medallists, Professor Adams, took up the problem; and on June 16, 1853, in a paper read before the Royal Society, pointed out an important error in the work of Plana and Damoiseau, and showed that the correction of this error most materially reduced the value of the acceleration. Three years later, Plana was induced by Adams's investigations to re-examine a portion of his own work; and in April 1856 he admitted the imperfection of his theory, and deduced a result agreeing with that of Adams. A little later, however, he withdrew this admission, and deduced a value differing both from that of Adams and his own original result.

Adams's investigations led to strong discussions between the chief mathematicians of the time, and his deductions were not at once accepted. They were opposed by de Pontécoulant, and in 1857 Hansen published his *Tables de la Lune*, in which the value adopted for the secular acceleration was 12″·18. In 1859, however, the investigation of this part of the Lunar theory was taken up by Delaunay, another of our medallists. Adams had shown that in a certain series in m^2, m^4, etc. (the term m^3 being absent) the term m^4 had been wrongly calculated, and that as a result the numerical value of the secular acceleration must be approximately halved. Delaunay, carrying his calculations to m^4, obtained exactly the same result as Adams; a result which he announced in January 1859. This induced Adams to publish the value he had already obtained, using terms involving m^5, m^6, and m^7, the result being to give the coefficient of secular acceleration the value 5″·7, a result subsequently reduced to 5″·64. Again Delaunay took up the matter, and on April 25, 1859, he communicated to the Académie des Sciences the result of his investigations, confirming Adams's new term: and, by carrying the approximations to the 8th order, deducing the value 6″·11.

Into the further stages of this important controversy it is unnecessary to enter, but ultimately the results of Adams were accepted. The acceptance of his value, or of a close approximation to it, leaves the remaining discrepancy between theory and the results of observation to be explained by some other cause or causes; a work with which Mr Cowell is at present prominently identified.

The next important step to be noticed in the development of the Lunar theory is the epoch-marking work of Dr G. W. Hill.

The features of that work were most admirably dealt with in the Address delivered by Dr Glaisher on the occasion of the Gold Medal being awarded to Dr Hill in 1887, and it would be quite impossible to summarise them here. It need only be said that—founded to some extent on a suggestion contained in the paper (to which reference has been already made) published by Euler in 1772, namely, that of employing moving rectangular co-ordinates, but embodying entirely novel methods of development, of the highest interest from the point of view of both the pure mathematician and the astronomer—Hill's work opened out a new region for theoretical research, at the same time introducing great simplifications in methods of practical calculation.

Many other distinguished names will no doubt occur to you as associated with the development of the Lunar theory, such as Airy, Donkin, Cayley, and Newcomb, but time will not permit of my entering into the details of their work on the present occasion. I must pass on to consider some of the salient features which have marked the development of the Lunar theory; and in doing this I desire to express my indebtedness to Dr G. W. Hill for much valuable information relating to this branch of my subject, which he has most kindly placed at my disposal.

The incessant call for greater precision in dealing with the motions of the Moon has led to frequent repetitions of treatment of this subject, so that we are now in possession of ten or eleven Lunar theories, each professing to go over the whole ground. The advance in precision is obvious from the fact that while Euler contented himself with about thirty periodic terms in the longitude, Professor Brown has nearly four hundred. As would be expected, each investigator has adopted such a method as, in his judgment, would lead most promptly to the desired end. These judgments, however, from the necessity of the case, can be only probable conclusions. Thus the Lunar theories we have now before us exhibit much variety.

The broadest division of these theories which can be made is into the two classes of *literal* and *numerical*. For the first, all the quantities on which the result depends are represented by algebraic symbols; while in the second, the investigators have attempted to shorten their labour by introducing at the outset the numerical values of as many of the quantities as the nature of the problem admitted. The much greater labour involved in the elaboration of a *literal* Lunar theory has brought it about that of our ten or eleven treatments of this subject, only three are *literal*, viz. those of Plana, de Pontécoulant, and Delaunay. But this method of treatment is much more satisfactory to the mathematical mind, while it also possesses obvious advantages over the numerical method. In the earlier days of the treatment of our problem it seems to have been thought nearly impracticable to adopt the literal method, and to Plana must be accorded the merit of having first elaborated such a theory. Professor Brown's theory is partially literal and partially numerical. Of the five parameters involved in the pre-

sentation of the Lunar co-ordinates, four are left indeterminate, and it is only the ratio of the month to the year that receives a definite numerical value from the beginning.

We next have to note other varieties of treatment. In the earlier period it was a favourite method to adopt the true longitude of the Moon as the independent variable; that is, in the first instance, the mean longitude, latitude, and reciprocal of the radius were determined in terms of the true longitude, and there remained the task of inverting these formulas. This was the method of all the early elaborations, except the last theory of Euler, to which reference has already been made. On many grounds it could, no doubt, be defended; but it seems that it was Poisson who first threw discredit on it. His pupil, de Pontécoulant, adopted the time as the independent variable, and so also did Hansen.

I must now direct attention to the most prominent of the peculiarities which mark our medallist's elaboration of the problem. This may be stated as the complete utilisation of the circumstance that, setting aside the rates of motion of the elements of the arguments of the periodic terms, the analytical expressions of the three co-ordinates are capable of being separated into portions, each factored by certain powers and products of the four parameters which Professor Brown has left indeterminate in his formulas. These factors have been termed "characteristics." The advantage of considering these portions is, that each can be determined independently of the adjacent, so to speak, portions; while the treatment depends on the portions of lower degrees, which have been precedently treated. The credit of having introduced this notion must be given to Euler, who employed it in his last treatment of the problem, published in 1772.

Very closely connected with the foregoing principle is the device of making the Moon's mean longitude disappear from the equations employed in the treatment. Instead of using co-ordinates referred to fixed axes, there are employed those referred to two axes in the plane of the ecliptic having a velocity of rotation equal to the motion of the Moon's mean longitude. This contrivance is also due to Euler.

From the use of these two principles results a distinguishing mark in the treatment. Every treatment must begin with a stage called that of the first approximation, from which, by degrees, a superior precision is attained. All the Lunar theories mentioned, except the two particularly described, start from the Keplerian ellipse, or this modified by moving lines of apsides and nodes, as a first approximation. But in the last theory of Euler, and that of Professor Brown, the first approximation is the variational curve, already somewhat roughly derived by Newton in the *Principia*. It is the fashion now to call this a periodic solution, as the inequalities of motion go through all their varieties in a lunation; but we may arrive at a notion of the matter more simply in the following manner:—The motion of the Moon largely depends on the constant called the eccentricity, and this constant

might have the value zero; in like manner, the motion might take place in the ecliptic; the solar eccentricity might be zero; and, in fine, the Sun might be supposed at such a distance that its action in disturbing the relative position of the Moon might be regarded as always parallel to its action on the Earth. Let all these four possibilities be fulfilled; the result is a greatly simplified set of differential equations, easy of solution, although methods of approximation must still be employed.

Having obtained this solution, we are prepared to advance further. Let it be granted that the four mentioned constants, instead of having zero value, have values so small that their squares and products may be neglected. This supposition gives rise to a set of equations denominated by M. Poincaré as "equations to variation." They are of the class known as "linear," and are generally more easy to integrate than those called "non-linear." Their most important quality is their being, with the exception of the known parts, the same in all the stages of the approximation. It thus results that a considerable portion of the calculations made for the second stage of the approximations is still available for all following.

It may be stated that the series which satisfy the differential equations of a Lunar motion belong to the class now known as Lindstedt series, or those resulting from the addition of terms, each the product of two factors, one being a constant, the other a sine or a cosine of an angular argument, the latter being equivalent to the sum of positive or negative integral multiples of a definite number of elementary arguments. In the restricted form of the Lunar theory treated by Professor Brown the definite number is four.

In the elaboration of the integration it is not only necessary to determine the constant factors of the series, but the derivation of the motion of the elementary arguments. The latter have similar forms with the coefficients, and, like them, cannot be determined at one step; we must be content to derive the successive portions in their turn. In the Lunar theory the matter is somewhat alleviated by the circumstance that the motion of two of the four elementary arguments may be regarded as known at the outset; it is necessary only to derive the rates of motion of the mean anomaly, and the mean argument of the latitude. At particular stages it becomes necessary to notice that the previously-used motion of one or the other of the arguments needs correction by the addition of a new set of terms.

When the Lindstedt series are substituted in the equations to variation, the result is a group of linear algebraical equations in number precisely sufficient to determine the coefficients, or the corrections to coefficients, as well as the corrections to the motions of the arguments, if there be any. For solving the above-mentioned group of equations the most feasible method of treatment to adopt is still that of successive approximations. The most important quantity to be noticed in this solution is the determinant

of the equations. Not unfrequently this quantity is much smaller than the coefficients from which it is derived. When this is the case the coefficients involved must be computed to a correspondingly greater degree of exactitude. In two or three cases the matter is so pressing that three more decimals must be added to the values of the quantities involved. This is the most troublesome circumstance attending the elaboration of a Lunar theory, and variation of method does nothing towards the removal of it. It is very vexing for the investigator to find that he must return on his steps, and push certain quantities to a higher degree of precision. The matter is so complicated that it is impossible to prescribe *a priori* rules for procedure. Delaunay in his Lunar theory has noted, at the foot of the page, all the places where such a modification of process was necessary.

Such, in brief, is an outline of the method of elaborating a Lunar theory to-day. In his paper, to which reference has already been made, published in vol. liii. of our *Memoirs*, our medallist stated that he had then (1897) been engaged for six years in attempting to develop the ideas contained in Hill's "Researches in the Lunar Theory," by calculating the coefficients of terms with certain definite characteristics, to which I have already alluded; and he defines the "characteristic" of any part of a coefficient as being that part of its expression which consists of powers and products of the eccentricities, the inclination, and the ratio of the mean parallaxes. He goes on to say: "Dr Hill had obtained these which had the characteristic unity, that is, which were functions of the mean motions of the Sun and Moon only, and also that part of the motion of the perigee which was a function of the same quantities; Adams had done the same thing for the motion of the node. It remained, therefore, to obtain the general equations, to put them into forms suitable for calculation, and to show how the other parts of the motions of the perigee and node might be obtained."

I must now notice the degree of advance in our knowledge of the Lunar motions, attained through the labours of Professor Brown. When Professor Newcomb made his comparison of Hansen and Delaunay, we were in doubt as to the value of some of the coefficients in longitude to the extent of half a second of arc at least; also the motions of the perigee and node were uncertain to correspondingly larger quantities. On the other hand, the degree of accuracy aimed at by our medallist has been such that there should be included the coefficients of all periodic terms in longitude, latitude, and parallax which are greater than $0''{\cdot}01$ of arc, and that the results should be correct to this amount. That he has been able to carry out such a programme is assuredly a matter demanding our heartiest congratulations; in fact, with such a notable advance one is almost inclined to say that there is nothing left to be desired; however, this phrase has been so often upset in the past that it would be unsafe to employ it.

A natural question here arises: "What will be the effect of

Professor Brown's researches on the accuracy of Lunar tables based upon them?" This is a question of great interest and importance, but in the present state of our knowledge it is one to which it is difficult to give a definite answer. It has, however, been my privilege to receive an expression of opinion from Dr G. W. Hill, who speaks with the highest authority, and this opinion I may be permitted to quote. He says: "Much as we rightly welcome the results of Professor Brown's devoted labours, we should be unwarranted in assuming that their employment in the Lunar tables would give rise to a marked improvement in the representation of observations. A slight one indeed might be expected; but it has been evident for some time that the Moon deviated from its calculated orbit more because it is subject to irregular forces, which we have not yet the means of estimating, than because the tables are affected by slight defects in the mathematical treatment of the forces which are already recognised. This circumstance in no sense diminishes the credit due to Professor Brown's work." This is a very weighty expression of opinion, and it indicates that there is yet ample work to be done by investigators of Lunar motions. I should add that such research has been most materially aided by the important work of our medallist, who, by giving accurate values to the known perturbations, has defined more clearly the further irregularities of which the explanation has yet to be ascertained.

I have perhaps, in this address, dwelt at somewhat undue length on certain matters of a more or less historical character, but my excuse is that the facts I have stated may serve to emphasise the difficulty and the onerous nature of the work in which our medallist has been engaged. That he has succeeded in making great advances in a field of research which has received the deepest attention from the leading mathematicians of the world for the past century or more is in itself a most eloquent testimony to his powers. It must be borne in mind that in a problem of this character, the solution of which depends upon so many diverse terms, the investigator has not only to acquire such knowledge of the various terms as will enable him to discard those of which the influence is unimportant, but he has also, in the case of those retained, to devise such methods of treating them as will enable them to be practically dealt with in a reasonable period. In both these respects our medallist has achieved admirable results. Early in his work of calculating inequalities whose characteristics are the first, second, and third powers of the ratio of the mean parallaxes of the Sun and Moon, and the same powers of the eccentricity of the Moon, Brown found that the forms of equations then available left much to be desired, and were apt to lead to errors in the practical calculations; and in a paper entitled "Investigations in the Lunar Theory" contributed to the *American Journal of Mathematics*, vol. xvii., he showed how these difficulties could be avoided and the labour of computation diminished.

The thoroughly practical character of Brown's method of work* is most striking. Speaking of the value of Euler's suggestions, he has himself said:—"The working value of a method of treatment is not really tested by the closeness with which the first or second approximation will make the further approximations converge quickly to the desired degree of accuracy; the real test is, perhaps, the ease with which the final approximation can be obtained. Here we have the essential difference between the present method and all other methods. The approximations of the latter proceed along powers of the disturbing force. Euler's idea was to approximate along powers of the other small constants present. This gives a most rapid convergence, and a degree of certainty in knowing the limits of error of the final results which no other method approaches."

In a letter which I have received from Professor Brown he modestly states that the only portions of his work presenting real difficulties were those arising from the *direct* and *indirect* actions of the planets. On approaching these problems he found the subject in a somewhat chaotic state, and it was necessary to clear the ground and get the theory into good shape. In doing this, the first requirement was to be able to compute the derivatives of the Moon's co-ordinates with respect to n = the Moon's mean motion. But in our medallist's theory the numerical value of n had been substituted, so that the derivatives could not be calculated directly from it. Delaunay's literal theory might have been used for the purpose, but, owing to slow convergence, Professor Brown did not consider it accurate enough. Under these circumstances he succeeded in finding a method for getting these derivatives accurately from his theory, in spite of the fact that the numerical value of n had been substituted. The idea which led up to this

* The records of our medallist's work have been largely contained in papers contributed to our Society. In May 1897 Professor Brown sent in Part I., chapters 1 to 4, of the paper entitled "Theory of the Motion of the Moon, containing a New Calculation of the Expressions for the Co-ordinates of the Moon in Terms of the Time," from which I have already quoted; and this was followed, in February 1899, by Part II.; in May 1900, by Part III.; and in January 1905, by the conclusion, Part IV. [Parts I. and II. of Professor Brown's paper are contained in vol. liii., Part III. in vol. liv., and Part IV. in vol. lvii. of the *Memoirs* of the R.A.S.] Besides this, he contributed a number of papers which have appeared in our *Monthly Notices*, namely, "On the Mean Motions of Lunar Perigee and Node," and "On the Theoretical Values of the Secular Accelerations in the Lunar Theory," abstracts of which appeared in March 1897; a paper entitled "Note on the Mean Motions of Lunar Perigee and Node," published June 1897; one "On the Verification of the Newtonian Law," which appeared May 1903; two papers entitled respectively "On the Degree of Accuracy of the New Lunar Theory and on the Final Values of the Mean Motions of the Perigee and Node," and on "The Parallactic Inequality and the Solar Parallax," published April 1904; one "On the Completion of the Solution of the Main Problem in the New Lunar Theory," published December 1904; and one "On the Final Values of the Coefficients in the New Lunar Theory," contained in *Monthly Notices* for January 1905.

method was first stated in a paper * contributed to the Cambridge Philosophical Transactions in 1899; and the method itself, which is believed to be quite new, was dealt with in a paper † contributed to the American Mathematical Society in February 1903. Since then the calculations have been performed, but are not yet published.

The calculation of the *indirect* inequalities gave considerable trouble, but Professor Brown was able ultimately to show in a paper ‡ contributed to the American Mathematical Society in February 1905 that it was not necessary to calculate the perturbations of the Earth by the planets in order to get the resulting effect on the Moon, but that it was possible to go straight to the disturbing function of the Earth by the planet. The calculations of the *direct* inequalities were completed last autumn, and Professor Brown hopes to publish them during the ensuing summer.

The precautions taken by our medallist to secure accuracy in the final results have been most refined. In accordance with the original programme, every coefficient in longitude, latitude, and parallax, which is so great as one-hundredth of a second of arc, has been computed, and is regarded as accurate to at least this amount, the results being really obtained to one-thousandth of a second. To avoid the occurrence of errors of computation, equations of verification have been computed at every step of the work, every page of the manuscript having, on the average, not less than two test equations computed. I am indebted to Mr Cowell for the remark that our medallist is the first Lunar theorist to use independent equations of verification, thus creating a higher degree of confidence in his results than could ever come from mere duplicate calculation. It was his device to form the equation for a small variation of this solution of Hill's equations. Says Mr Cowell:—"The numerical application of this device was rendered possible by calculating series for various complicated fractions of the co-ordinates in Hill's variation curve. The utility of the plan is obvious as soon as it is got into working order, and its conception implies rare insight on the part of our medallist. It lies at the root of his success in obtaining more accurate results, with less labour than his predecessors. He has also obtained theorems by which the higher parts of the motion of the perigee and the node may be calculated in advance of the corresponding group of periodic terms."

For the motions of the perigee and node, the final values obtained, and a comparison of these values with the results of

* "On the Solution of a Pair of Simultaneous Linear Differential Equations which occur in the Lunar Theory," *Cambridge Philosophical Transactions*, vol. xviii.

† "On the Formation of the Derivatives of the Lunar Co-ordinates with Respect to the Elements," *Transactions of the American Mathematical Society*, vol. iv.

‡ "On a General Method for Treating Transmitted Motions, and its Application to Indirect Perturbations," *Transactions of the American Mathematical Society*, vol. vi.

observations, were given in the paper published in the number of the *Monthly Notices* for April 1904,* to which reference has already been made. In giving these values our medallist pointed out that there was one constant of which the observed value was so far doubtful as to affect the results by as much as the tenth of a second, this constant being the ellipticity of the Earth. As there appeared to be two competing values for this constant, namely, $\frac{1}{292\cdot9}$ and $\frac{1}{296\cdot3}$, between which no definite choice could be made, Professor Brown decided to calculate the results for the two values. The final results, with the portions of which they are made up, are given in the subjoined table :—

Final Mean Values of the Annual Mean Motions of the Perigee and Node.

Epoch 1850·0.

		Perigee.	Node.
Solar Action	Char^{c}. I.	+148 524″·92	−69 287″·90
	,, e^2	− 519·31	− 616·09
	,, γ^2	− 1 739·85	+ 260·59
	,, e'^2	+ 156·27	− 25·46
	,, α^2	+ 2·24	− 1·11
	,, e^4	+ ·04	+ ·07
	,, $e^2\gamma^2$	+ 6·72	− 1·70
	,, γ^4	− 1·51	+ ·05
	,, $e^2e'^2$	− ·99	− ·57
	,, $\gamma^2e'^2$	− 1·61	+ ·08
	,, rem^{g}.	·00±·04	·00±·02
Terms in No. 2		− ·70	+ ·20
Terms in No. 3		+ ·01	− ·01
Planetary direct		+ 2·66 } ±·06	− 1·42 } ±·03
Planetary indirect		− ·20 }	+ ·06 }
Figure of Earth (α)		+ 6·57	− 6·15
Figure of Earth (β)		+ 6·41	− 6·00
Calculated sum (α)		+146 435·26±·10	−69 679·38±·05
Calculated sum (β)		+146 435·10±·10	−69 679·23±·05
Observed		+146 435·23	−69 679·45
C − O (α)		+ 0·04±·10	+ 0·08±·05
C − O (β)		− 0·12±·10	+ 0·23±·05

Note.—The "Figure of Earth" values "(α)" correspond to an ellipticity of $\frac{1}{292\cdot9}$, and those "(β)" to an ellipticity of $\frac{1}{296\cdot3}$.

* A slight correction to the values there given will be found in *Monthly Notices*, vol. lxv. p. 276. This correction has been made in the values as now given.

For the theoretical secular accelerations the values finally arrived at by our medallist (as given in his paper published in *Monthly Notices* for March 1897) are as follows:—

Theoretical Values of the Secular Acceleration per Century.

The Mean Motion	$+ 5''.91 \pm 0''.02$
The Perigee	$- 38''.9 \pm 0''.1$
The Node	$+ 6''.56 \pm 0''.02$

In devising the details of his research, our medallist arranged the work so that considerable proportions could be done by computers; but, as a matter of fact, only one—Mr Ira L. Sterner, of Haverford College, of whose ability and accuracy Professor Brown speaks in the highest terms—has been so employed. It may be interesting to quote here some details given by our medallist as to the time and labour expended on the work. He states: "From 1890 to 1895 certain classes of inequalities were calculated, but the work was only begun on a systematic plan, which involved a fresh computation of all inequalities previously found, at the beginning of 1895. Mr Sterner began work for me in the autumn of 1897, and finished it in the spring of 1904, though neither of us was by any means continuously engaged in calculation during that period. He spent on it—according to a carefully-kept record—nearly three thousand hours, and I estimate my share as some five or six thousand hours, so that the calculations have probably occupied altogether about eight or nine thousand hours. There were about 13,000 multiplications of series made, containing some 400,000 separate products; the whole of the work required the writing of between some four or five millions of digits and *plus* and *minus* signs."

Professor Brown has, as I have stated, completed his solution of the problem of three bodies for the case of the Sun-Earth-Moon, and has achieved an accuracy very far in excess of that of any of his predecessors; while he has done this by methods involving striking elegance and originality, and showing great powers of resource. He has, however, by no means finished his labours. As he himself pointed out, in announcing the completion of the main problem, much still remained to be done before it was advisable to proceed to the construction of tables. On this work our medallist is now engaged, and we may rest assured that he will continue to bring to bear upon it that energy and power of organised inquiry which have enabled him already to secure such brilliant results. We may, I think, further hope that in the present award he may find some encouragement in his labours.

I much regret that Professor Brown is not with us this evening to receive the medal personally, but a combination of circumstances—amongst them the serious illness of a relative—has rendered it impossible for him to cross the Atlantic at the present

time. This being so, I have been in communication with Sir Edward Grey, H.M. Secretary of State for Foreign Affairs, and I am glad to say that he has kindly arranged for the medal to be forwarded in the Foreign Office bag to His Majesty's Chargé d'Affaires at Washington, by whom it will in due course be transmitted to Professor Brown.

I will now ask Mr Lewis to receive the medal on Professor Brown's behalf, and to transmit it with our most sincere hope that he may long be spared in full health and strength to carry out the important researches to which he has devoted himself.

Before passing to other business, there is another matter connected with our medallist on which I should like to say a few words. I have not alluded to it in my address, because it has nothing to do with the award of the medal, but it will, I think, be of interest to the Fellows generally. As many present are aware, Professor Brown is an Englishman who has been long resident in America, and who has for the past sixteen years been connected with Haverford College. That association will, however, be broken in the ensuing summer, and next autumn Professor Brown proceeds to Yale University. It is exceedingly gratifying to know that his work on the Lunar theory, which he has been able to carry on at Haverford under most favourable conditions, will not be interrupted by this change. By a letter received from Professor Brown, I learn that not only have the Yale authorities recognised the importance of his work by arranging special facilities for its continuance, but they have also most generously undertaken to provide the funds required for both the preparation and the publication of the Lunar Tables which will form the natural outcome of our medallist's labours.

The Meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected: —

President.

H. F. Newall, Esq., M.A., F.R.S.

Vice-Presidents.

Sir W. H. M. Christie, K.C.B., M.A., D.Sc., F.R.S., Astronomer Royal.
Sir David Gill, K.C.B., LL.D., D.Sc., F.R.S.
Major P. A. MacMahon, D.Sc., F.R.S.
W. H. Maw, Esq.

Treasurer.

Major E. H. Hills, C.M.G.

Secretaries.

Thomas Lewis, Esq.
S. A. Saunder, Esq., M.A.

Foreign Secretary.

Sir William Huggins, K.C.B., O.M., LL.D., D.C.L., F.R.S.

Council.

Sir R. S. Ball, M.A., LL.D., F.R.S., Lowndean Professor of Astronomy and Geometry, Cambridge.
Bryan Cookson, Esq., M.A.
P. H. Cowell, Esq., M.A., F.R.S.
A. C. D. Crommelin, Esq., B.A.
F. W. Dyson, Esq., M.A., F.R.S., Astronomer Royal for Scotland.
Alfred Fowler, Esq., Assistant Professor of Physics, South Kensington.
J. W. L. Glaisher, Esq., M.A., Sc.D., F.R.S.
J. A. Hardcastle, Esq.
A. R. Hinks, Esq., M.A.
E. B. Knobel, Esq.
E. J. Spitta, Esq.
H. H. Turner, Esq., D.Sc., F.R.S., Savilian Professor of Astronomy, Oxford.